PRODUCT ENGINEERING

MARCH
1934

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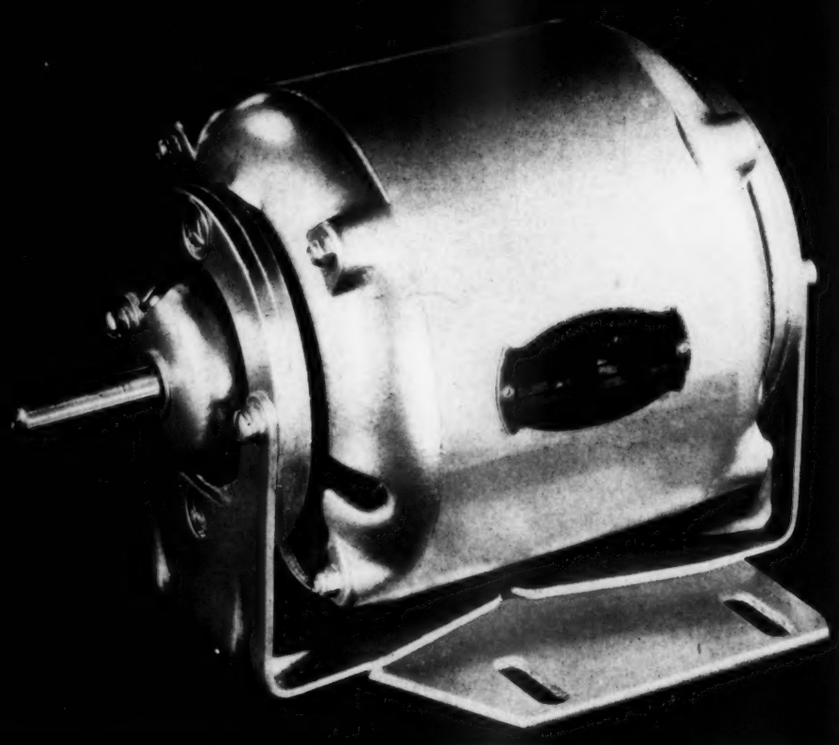
Controls for Automatic Operation
Station Clutches—Jewel Bearings
Determining Customer Preferences
Silver for Contacts—Gear Trains

•

Mechanical Design • Product Development

McGRAW-HILL PUBLISHING COMPANY, INC.

Delco Motors



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Most motors are quiet when they leave the factory . . . but how about the *second* and *third* year of operation? The normal quietness of Delco motors, due to proper balance and precision manufacture, is well known; and now, with the special vulcanized rubber cradle mounting, this quietness becomes even more appreciated. The rubber is vulcanized both to the motor ring and to the supports, allowing full rotative flexibility, yet curbing any tendency of the shaft to twist out of line. So successfully does this new Delco mounting isolate vibration and hum from the base that the quietness of Delco motors is rapidly becoming a by-word in the electrical manufacturing industry. It is a simple matter to engineer a Delco motor into a good product . . . and the result is highly gratifying to manufacturer, dealer and ultimate owner.

Delco Products Corporation · Dayton, Ohio

PRODUCT ENGINEERING

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IN THIS ISSUE

Mechanical Design—Formerly used only in watches and the most delicate instruments, jewel bearings are now being used in electric meters, gages, scales and wherever else their remarkable qualities give the product otherwise unattainable superiority. Hence the comprehensive article setting forth the types of jewel bearings and their mountings.

In the October, 1933, number there was an article on laminated metals. A fitting companion article is the two-page spread in this issue showing the development of typical designs of electrical contacts made of laminated and striped silver.

Mechanisms—Station clutches may seem to be complicated, but the author of "Typical Mechanisms for Station Clutches" reduces the problem to simple fundamentals.

In his concluding article on gear trains, James A. Hall illustrates his procedure with practical examples.

Motors and Controls—A glance into the past and a look at the present gives a hint of the future. The article on motor and control applications may make many engineers think and perhaps even do more than just think.

COMING ISSUES

In the April number will be found a number of articles that will be of timely interest because of the first exposition of The Alliance of Art and Industry to be held in April in New York City. Some of the outstanding exhibits will be described and there will be brief items by some of the leading industrial engineers.

Included in the same number will be articles on decorative finishes, die-castings and molded plastics. On the subject of stresses, R. V. Baud will show how to design fillets containing a minimum amount of material and free from stress concentration. Readers interested in electric motors will find the check-sheet on the selection of motors not only of interest but also of practical value.

KENNETH H. CONDIT
Editor

GEORGE F. NORDENHOLT, *Managing Editor* · R. W. CARSON, *Assistant Editor* · LEONARD CHURCH, *Cleveland* · PAUL WOOTON, *Washington*

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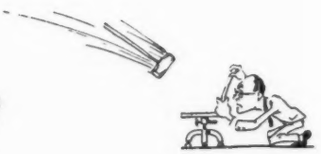
Intimate Correspondence



A Clipper's Complaint

PRODUCT ENGINEERING
NEW YORK

As a subscriber and reader of *Product Engineering* I desire to make a suggestion which I believe will meet with the approval of a large number of subscribers. Being one of the type who cuts a magazine, rather than indexing it, I have experienced considerable trouble in securing a proper arrangement of the data so removed.

For example, in the February issue of *Product Engineering* pages 58 and 59 contain Part II of Typical Designs of Gibs and Guides. I am sure that any number of subscribers like to file these sheets of typical designs in the back of their reference sheet file. Yet in the February issue one of these typical design sheets contains a part of the article on Anti-Friction Bearing Mountings for Heavy Duty Spindles—II. This is an article of intense interest to every engineer in the machine design, construction or maintenance fields, and which most of them would probably like to preserve. Then the other typical design sheet contains part of the article on Laminated Plastics for Bearings and Spinning Pots. While this article probably is not interesting to as many as the above mentioned article on bearings, it is, in view of the rapidly increasing use of plastics in the various fields, an article well worth preserving.

Now the only way these four articles plastics also contains part of the article dealing with Practical Data and Formulas for the Design of Worm Gears—II.

Now the only way these four articles could be filed in a data book and all four articles preserved would be to keep the sheets in the same order that they are in the magazine. This would prohibit the placing of these articles in their order, following previously published articles on the same subjects.

I have been wondering whether or not it would be practicable to print the typical design sheets on the same manner that the reference book sheets are printed, and also whether articles such as those mentioned above could be started on the pages bearing odd numbers, and the space at the end of the article, not used for the article proper, be filled with duscussion, comment or brief articles, which could be contained in such space and of which I am sure you receive a large number that you are at present unable to print.

Would such a layout be practicable or would it add so much to the cost of the magazine as to be detrimental to the continued popularity at present enjoyed by *Product Engineering?*

C. M. DUNAVAN,
Roanoke, Va.

AS Mr. Dunavan has probably guessed, it isn't so easy to balance a professional magazine so that appearance, field coverage, provisions for the reader who clips and files, authority and liveliness are all adequately covered. We promise to do our best for him and his fellow clippers but we may have to fall back on our offer to supply extra clippings or copies to those who want them when nothing else is possible.

Another

PRODUCT ENGINEERING
NEW YORK

Could you spare us a Page 452 and 453 of the December 1933 *Product Engineering?* I find I want to file all three articles covering "Photo-Elastic Analysis"—"Initial Wear" and "Wire Locks and Snap Rings for Fastenings." This is in connection with copy you are sending to my home.

Auburn Ball Bearing Company
F. A. COLLINS, Engineer

WE add this one to illustrate how this matter of extra clippings is handled according to routine. His pages were mailed the same day.

Designers

PRODUCT ENGINEERING
NEW YORK

In February *Product Engineering*—on page 73—you have a list of free lance designers. We are wondering whether it would be possible to furnish us with the addresses of these designers.

Fox Company,
E. J. MURRAY

OF course we can furnish such addresses, and we do, gladly. But this looks like a good place to call attention to the placement service of the National Alliance of Art & Industry, 30 Rockefeller Plaza, New York. This organization keeps the records of industrial artists and designers and stands ready to recommend those with the requisite experience for any particular job.

More Practical

PRODUCT ENGINEERING
NEW YORK

I would suggest that you make the monthly charts a little more practical, ones which could be used daily instead of only for research work.

GORDON JACOBS,
Cincinnati, O.

NOT all charts are likely to be useful to all readers. Evidently Mr. Jacobs has run into a series that doesn't fit his immediate needs. But if he will run back over earlier numbers of *Product Engineering* we are sure he will find that, on the whole, there is a fair percentage of highly practical information in these pages. These isn't much handbook material there, because we assume that readers of *Product Engineering* have the handbooks they need. Finally, if any reader will request charts on any particular subject of more than local interest we will do our best to get and print them.

Catching Customers?

PRODUCT ENGINEERING
NEW YORK

Will you be kind enough to supply us with the names of producers of machinery to manufacture mouse traps of wire and wood? Also the names of large producers of steel wire such as is used in small mouse traps.

A Manufacturer of Popcorn Products

HERE'S a queer one. Have the mice been at the warehouse? Or is the plan to include a trap with every package to be sure of catching customers?

Please pardon the levity.

Toward NEW HORIZONS

A LOT of wise manufacturers are broadening their lines these days. . . . Normal markets are shrunk. Competitive conditions in their own fields are tough. To raise sales curves, they turn to the manufacture of additional products.

If your company is going to expand its line, you'll naturally choose a product that can be made with present equipment. But there are certain to be a few parts your plant is not geared to produce. Do you want to invest in new equipment? Not if you can help it! *That* is where Scovill steps in. . . .

This organization is equipped to make those metal parts for which you might otherwise have to buy equipment, to design and fabricate them—in quantity—efficiently—speedily—*economically!* Scovill manufactures for more than 3000 companies in practically every line of industry. Scovill's complete facilities, trained men, years of experience, can help *you* avoid production worries and additional overhead.

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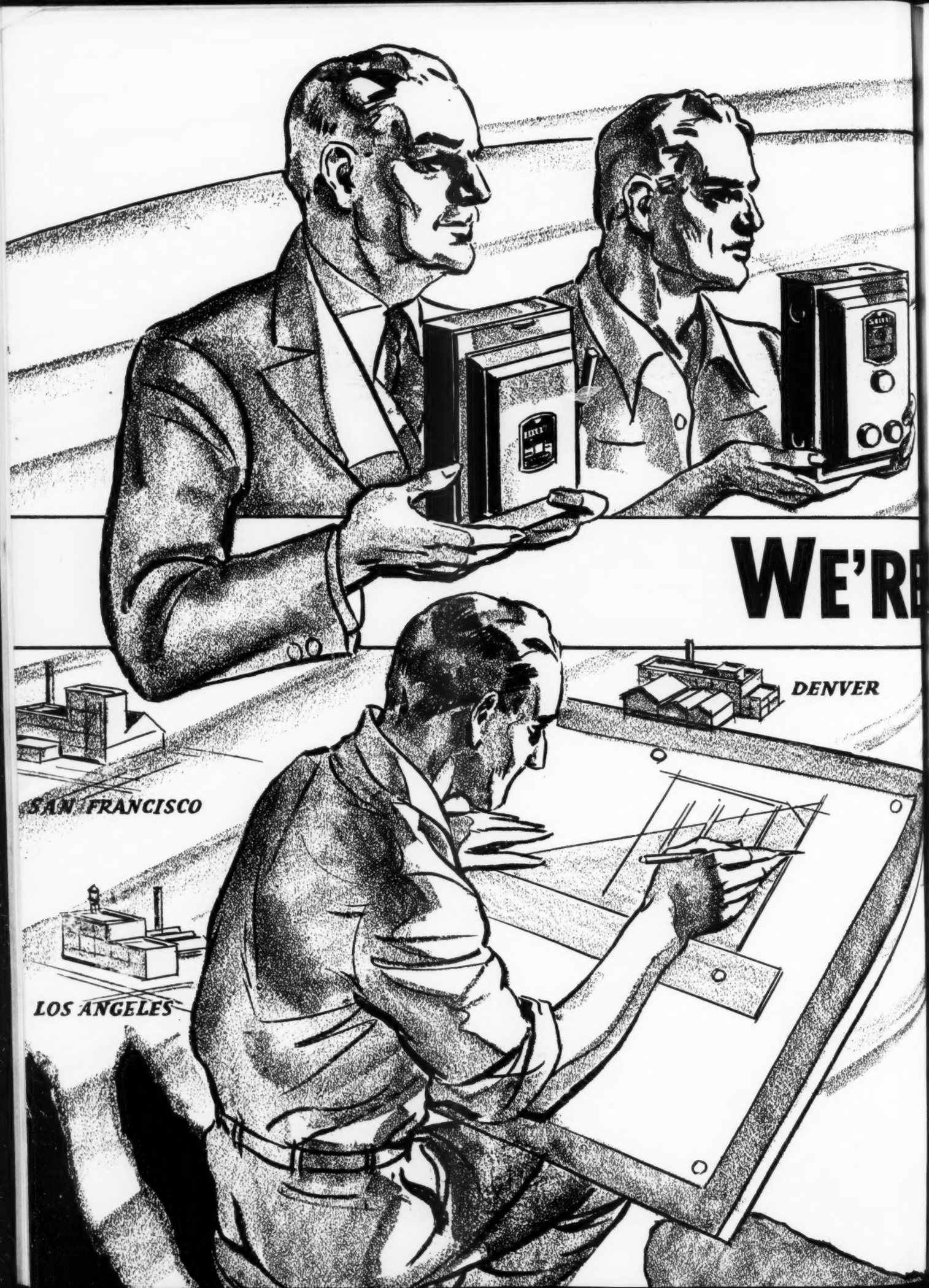
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PRODUCT ENGINEERING

KENNETH H. CONDIT, *Editor*

MARCH, 1934

MCGRAW-HILL PUBLISHING CO., INC. VOLUME FIVE, NUMBER THREE

Faulty Electrical Design?

SAYS the chief engineer of a prominent machine tool building organization: "The rapidity with which we adopt and extend the application of electrical devices to machine tools depends largely on the manufacturer of the electric parts. We had to wait years before we could obtain motors small enough to be fitted into the machine housing. Less than ten years ago we could not obtain automatic controls that were small enough, and in many instances the electrical parts were not strong enough mechanically. They did not last and were not dependable." Admitting that great advances in the design and construction of electric drive and control units have been made, he goes on to say that he believes that "some of our electrical apparatus can be improved greatly from the mechanical standpoint," which puts it pretty squarely up to the designers and manufacturers of this apparatus.

As for compactness and adaptability, the Germans have shown what can be done. For several years their machine tools have been distinguished by cleanly built-in drive, control and measuring units, many of which have had no counterparts over here. And this feature has been about the only one on which they have an advantage over our own machine tools.

What is true of the drive units and control apparatus for machine tools is equally true of the corresponding equipment for other power-driven machines. Machine tools have been taken as an example here because of the availability of the letter from a machine tool chief engineer, and because we have on pages 106 and 107 pictorial evidence of the truly remarkable progress in machine tool design that has been made in thirty years.

But progress in the electrification of power-driven machinery is not a problem that can be left on the electrical designer's doorstep. Because of the rapid improvement in the design of electrical apparatus the mechanical designer must keep in close touch if he is to take advantage of these developments as they come along. The best results are obtained only when the designer of the electrical parts has a full appreciation of the mechanical requirements, and the machine designer is equally aware of the possibilities in the application of electric drives and controls.

Dust Off the Old Plans

WIDE-AWAKE manufacturers and utility men are getting out some of their plans prepared years ago and pigeonholed because the high cost of power made them uneconomical. The big experiment with Federal production and distribution of electric power in the Tennessee Valley will go far to determine whether we can expect a general supply of power at a fraction of the present cost. If the answer is positive many of these old plans and designs will suddenly become thoroughly practical, and the way will be cleared for far-reaching developments in power-using machinery and equipment.

In the preceding editorial we pointed out how materially the recent developments in electrical control and power units have affected machine design. Newly discovered alloys and newly available materials can have an equally significant effect.

For instance, Mr. Wadhams, director of research of the International Nickel Company, pointed out in a lecture that crossing of the various families of alloy steels dates only from the World War. Up to that time each one went serenely on its way and it was not until a shortage of certain alloying elements forced experimentation that the work started which has culminated in our present high-strength and heat-resistant alloys.

Dust off the old plans occasionally to see whether recent discoveries in materials, reductions in power costs, or new developments in parts and mechanisms have not made them economical. It will pay.

Typical Mechanisms for STATION CLUTCHES

Innumerable variations of these station clutches may be designed for starting and stopping machines at selected points in their cycle of operation

HERMANN HILL

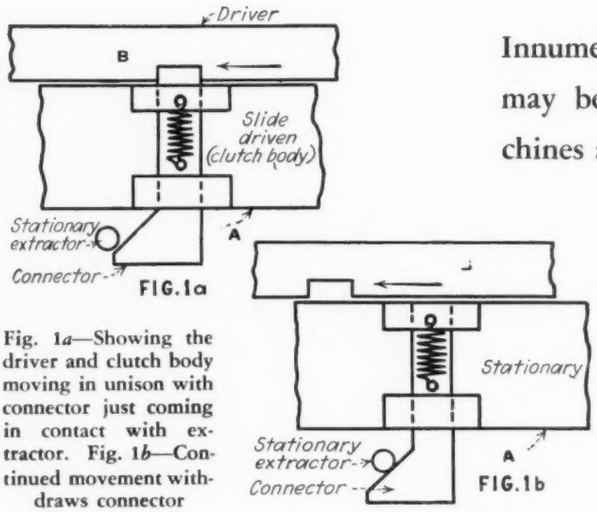


Fig. 1*a*—Showing the driver and clutch body moving in unison with connector just coming in contact with extractor. Fig. 1*b*—Continued movement withdraws connector

AS IN the design of all devices, innumerable different arrangements of the elements of the mechanisms that comprise station clutches are possible, but every design will be merely an evolution from one of a limited number of possible combinations. To be able to readily determine the possible variations in the arrangement of the elemental parts of a given mechanism it is merely necessary to understand thoroughly the manner in which these parts enter into the function of the mechanism. With such a procedure it will be much easier to visualize the various possible forms of the mechanism and thereby arrive at a design that will be simplest and require the least number of parts. This will sometimes result in a departure from conventional designs. However, if the unconventional design is more suitable it is better to break away from the orthodox and create mechanisms of original form that will be better fitted into the general design and character of the machine. Of course, wherever possible, one should adhere to the conventional design.

Station clutches for the purpose of stopping or starting a machine or machine element at a definite predetermined point may be used for controlling either linear motion or rotary motion. And they may be designed to stop and start the machine member at any number of points or stations in the cycle of operation. Perhaps the best known example of a one-station clutch is that used on punch presses.

In the Fig. 1*a* is shown the fundamental mechanism of the station clutch in its simplest form. The slide *A* is connected to the driving member *B*, the two members moving in unison, the connection between *A* and *B* being through the medium of a sliding element called the connector. In the position as shown in Fig. 1*a*, the sliding connector is held in the recess in element *B* by means of the spring as shown.

In order to operate as a station clutch it is necessary to provide some means whereby the driven element *A* can be disconnected from the driver *B* at any desired point. To do this automatically, it is necessary to provide some means whereby the connector will be withdrawn from the recess in the driver *B* at the predetermined point where it is desired to stop the motion

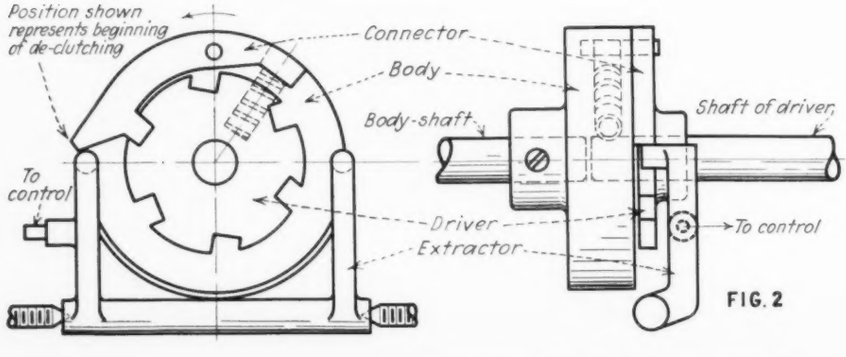


Fig. 2—A two-station clutch in which the stations are 180 deg. apart. By using only one extractor arm, this mechanism can be used as a one-station clutch

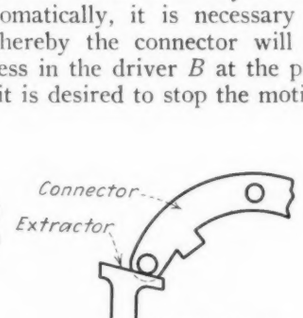


Fig. 3—A modification of the cam extractor shown in Fig. 2

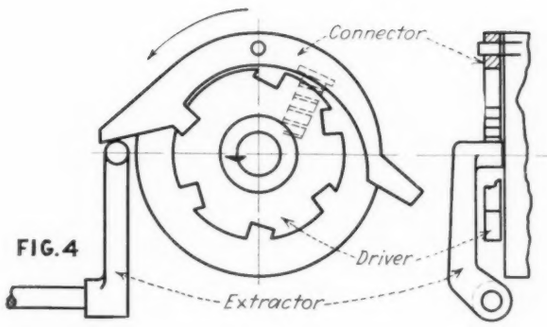


FIG. 4

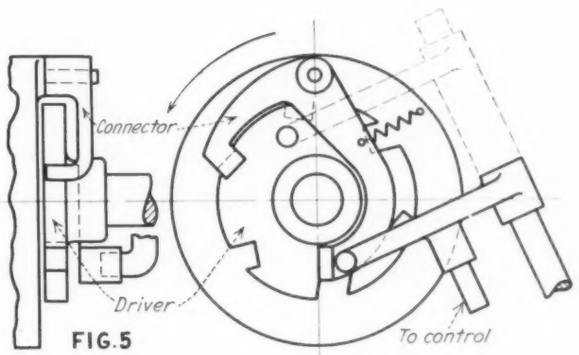


FIG. 5

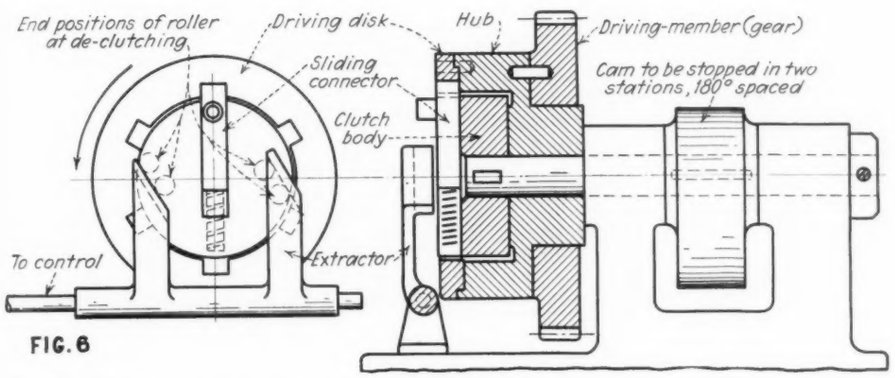


FIG. 6

Fig. 4—A single extractor two-station clutch with the stations 180 deg. apart. Only one extractor is required because the connector has two cams

Fig. 5—A design of one or two-station clutch using a dual extractor, a compact design because there are no parts projecting beyond the body

Fig. 6—End and longitudinal section of a design of a station clutch using internal driving recesses

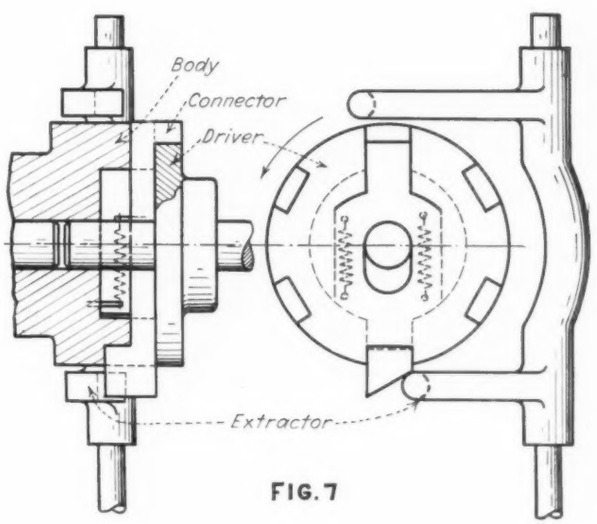


FIG. 7

Fig. 7—A one or two-station clutch, depending on the use of a single or a dual extractor, the stations being spaced 180 deg. apart

of *A*. The most obvious means of sliding the connector out of the recess in *B* is to utilize its movement as a part of the driven element *A*. Thus, there can be put on the connector a cam surface that will come in contact with a stop pin located at the desired point. After the cam strikes the stop pin, the continued forward movement of the connector or its cam surface relative to the stationary pin compels the connector to move axially, thereby withdrawing it from the recess in member *B*. Part *A* then comes to rest while the driver *B* may continue to move forward.

For the present purposes, the movement of *B* may be considered as reciprocating. To again connect *A* to *B* on the latter's return stroke, it is merely necessary to contrive some means to withdraw the pin, thereby permitting the connector to be again forced into the recess in member *B* by the action of the spring as shown. Thus, when the recess in *B* again reaches a position opposite the connector, the latter will be forced into the recess and elements *A* and *B* will then be connected and again move as a unit.

The elementary parts as described are all that are required to start and stop the driven member at predetermined stations. In the example it was assumed that the driver and driven elements both had linear motion. This is equivalent to rotary motion at a radius of infinity. It can readily be seen that if the elements *A* and *B* were rotated about a center at a finite radius, the operation of this fundamental mech-

Fig. 8—Another design of one or two-station clutch, using a single or dual extractor with stations spaced 180 deg. apart

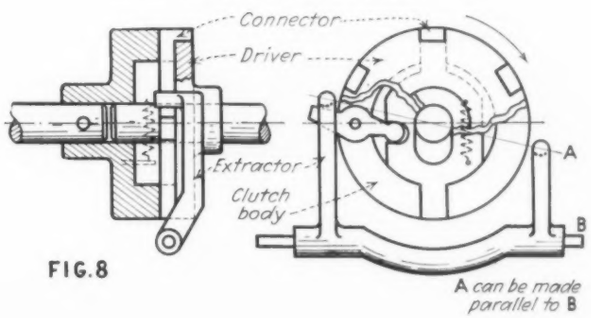


FIG. 8

anism would not be altered. Thus, the same basic mechanism can be applied for rotary motion as well as linear motion. And regardless of the details of the design of the clutch, the mechanism will always primarily consist of the four basic elements, which are the driven member, the connector, the extractor and the driver.

Applying this fundamental mechanism to rotary motion makes possible two distinct types of station clutches. In one of these the connector moves radially as it engages and disengages the driven member. In the other type, the connector moves axially, that is, parallel to the axis of the clutch body. Regardless of the details of the design, such clutches consist of the driver in the shape of a disk and having recesses in its periphery and mounted on a shaft co-axial with the driven member. The driven member will be a disk or cylindrical body with the connector of the required type mounted upon it and actuated by a return spring for engaging it with the driver. This whole assembly is mounted on a shaft or attached to the unit that is to be rotated and controlled by the station clutch.

In the accompanying illustrations are shown the distinctive features of various possible constructions, all based upon the same elements of the mechanism. For the sake of clarity, the designs of these station clutches are shown in schematic form. It will of course be necessary for the designer to determine the forces and loads, detail dimensions and the material specifications.

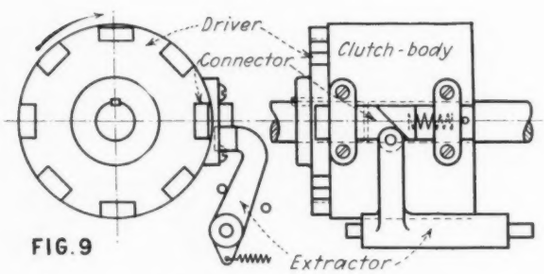


Fig. 9—A design of one-station clutch of the axail conector type

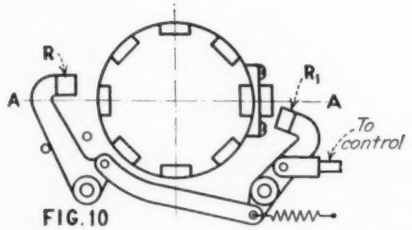


Fig. 10—In this design of two-station clutch the roller *R* and R_1 of the extractor may also be arranged on the center line *A-A*

In addition to the basic elements, station clutches should be provided with an auxiliary device to prevent clicking or "ratchetting." This clicking is frequently heard in punch presses when they are running idle. Devices for preventing clicking may be constructed to suit the designer's preference as to arrangements and form. Because this "ratchetting" mechanism does not enter into the functioning of the clutch, it has been omitted in all of the drawings of the complete clutches shown here, but several designs of such mechanisms are shown separately.

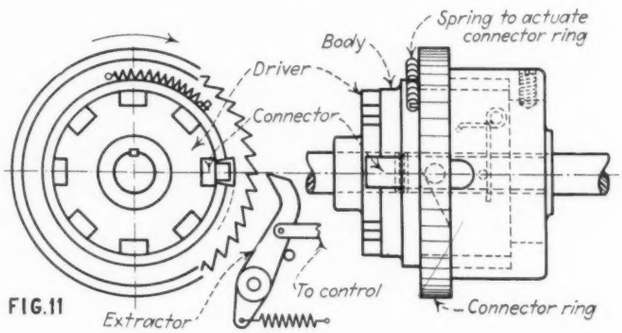
Another auxiliary feature that might sometimes be necessary is a brake of some kind or a positive lock to prevent the clutch body from overrunning the station because of inertia. But in most instances, this device can be dispensed with because the resistance to rotation of the clutch body is usually sufficient to hold it stationary.

Summarizing, station clutches are comprised of the following elements: (1) driven body, (2) connector, (3) extractor (the stop pin or cam on the stop arm), (4) driver. The driver usually consists of a disk with notches in the rim or with holes near the periphery.

Possible applications for the use of this type of clutch are:

1. Single-station Clutches (Figs. 2 and 3, using only 1 extractor).

Fig. 11—A typical design of multi-station clutch of the non-selective type for instantaneous stopping at any position



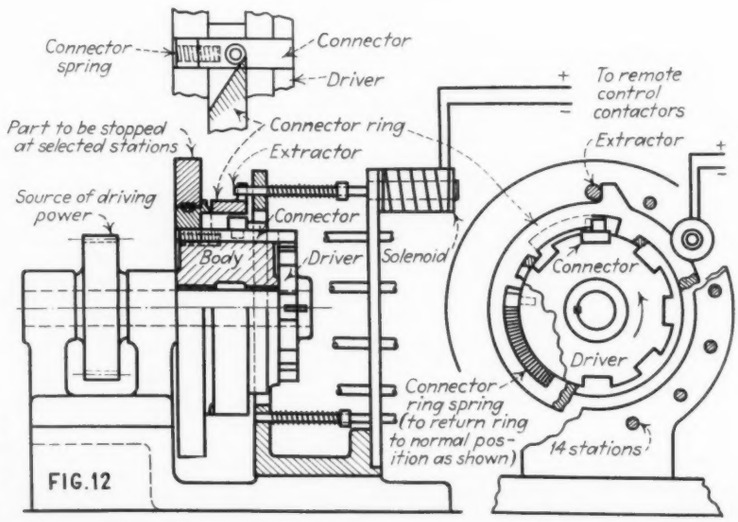


Fig. 12—A design of multi-station clutch with remote control. The extractor pins are actuated by solenoids which either hold the extractor pin in position against spring pressure, or release the pin

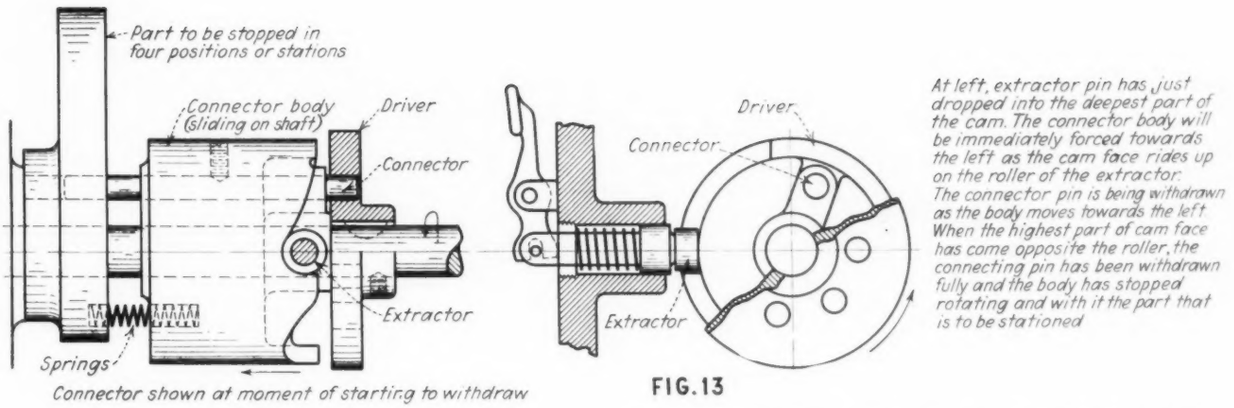

Part to be stopped in four positions or stations
Connector body (sliding on shaft)
Driver
Connector
Extractor
Springs
Connector shown at moment of starting to withdraw
Driver
Connector
Extractor
At left, extractor pin has just dropped into the deepest part of the cam. The connector body will be immediately forced towards the left as the cam face rides up on the roller of the extractor. The connector pin is being withdrawn as the body moves towards the left. When the highest part of cam face has come opposite the roller, the connecting pin has been withdrawn fully and the body has stopped rotating and with it the part that is to be stationed
FIG. 13

Fig. 13—A four-station clutch that can be modified to have one or any number of stations, using one extractor as shown or any number of extractors. In the design shown, the part can be stationed four times in one revolution or any station can be skipped

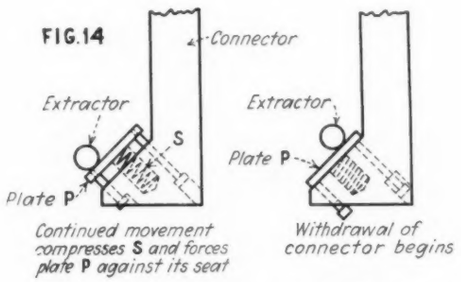


Fig. 14 — Design of auxiliary silencing device. Spring *S* is released when the connector is clear of the driver and thereby pushes the connector to give a positive clearance between it and the face of the driver

Fig. 15—An auxiliary silencer as adapted to the connector of a clutch to prevent clicking and ratcheting

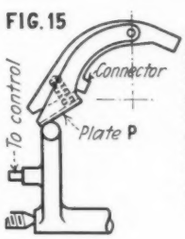


FIG. 15
To control
Connector
Plate P
Plate P is closed against cam face as the latter approaches the extractor. After withdrawal of connector from notch (recess in driver) the spring will force connector still further away from driver so as to be fully clear

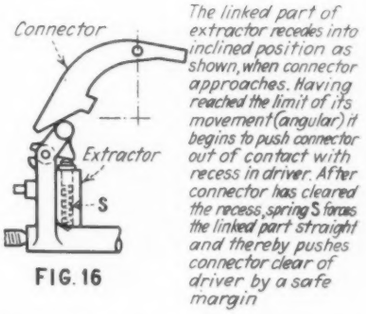

Connector
Extractor
S
FIG. 16
The linked part of extractor recedes into inclined position as shown, when connector approaches. Having reached the limit of its movement (angular) it begins to push connector out of contact with recess in driver. After connector has cleared the recess, spring S forces the linked part straight and thereby pushes connector clear of driver by a safe margin

Fig. 16—The silencer is a part of the extractor and after the connector has cleared the recess the compressed spring *S* forces connector clear of the driver by a safe margin

2. Two-station Clutches (usually 180 deg. between stations as illustrated in Fig. 4).
3. Multi-station Clutches
   (a) selective stations (illustrated in Fig. 12);
   (b) non-selective stations (illustrated in Fig. 11).

Numerous variations are possible in the arrangement and construction of the extractor. As will be shown, in some designs it is necessary to actuate the connector not directly with the extractor but through an intermediate part, as illustrated in the designs shown in Figs. 8, 11 and 12.

In the operation of the clutch, the connector is forced out of engagement with the driving member by the combined action of the driver and the extractor. The interesting feature, and one which requires careful design, lies in the fact that the torque of the driver is utilized to force the connector out of contact with the recess of the driving disk. As the connector strikes the extractor, the latter forces the connector out of the recess against the frictional resistance created by the pressure of the driving face of the recess against the connector. But the moment that the connector is free of the recess there is no longer any force available to continue its movement. This explains the need for an auxiliary device for preventing the ratchetting noise.

It is evident that the connector cannot move beyond the face of the recess. It is, therefore, pushed in a position where it just clears the edge of the recess and touches the periphery of the disk of the driver. In this position the face of the connector will rub against the disk, thereby causing a click every time it passes a recess. If the clutch body should move slightly, this clicking will increase.

To prevent this, a device called a "silencer" may be used. It consists primarily of a spring which is preloaded before the connector starts to withdraw from the recess of the driving disk. The spring may be a part of the connector or it may be a part of the extractor. It is compressed between the connector and the extractor when these parts are pushed together and is held compressed until the connector finally clears the recess. As soon as the connector is clear of the recess, the force of the compressed spring moves the connector a short distance beyond the rim of the driver. This puts the extreme face of the connector a safe distance away from the rim, thereby making it impossible to strike the edges of the recess.

In Figs. 14, 15 and 16 are shown the spring and striking plate which constitute the necessary elements of this device. If correctly designed, there will never be any danger of the clutch clicking or ratchetting.

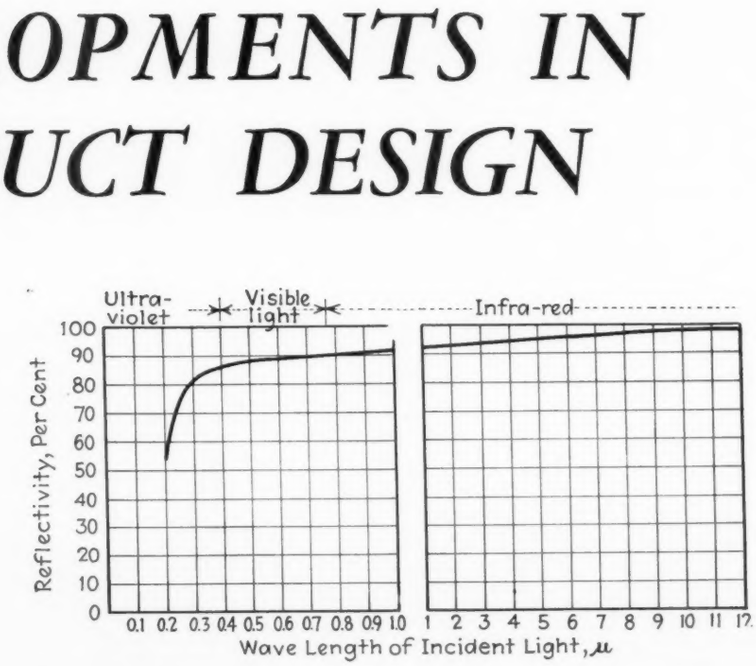
DEVELOPMENTS IN PRODUCT DESIGN

• New Aluminum Reflectors

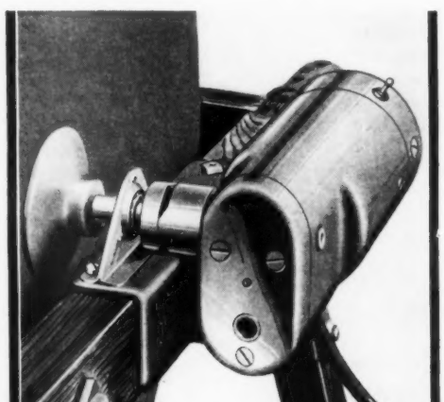
The discovery of a new type of reflecting surface with a base of aluminum was announced at a recent meeting of the Illuminating Engineering Society, held in Cleveland. As shown in the accompanying curve, aluminum finished by the new process has a reflectivity as high as 90 per cent—not far below that of silver—and, in addition, does not tarnish in industrial atmospheres, is resistant to weather, and can be readily cleaned by washing with soap and water.

In using aluminum for reflectors, the usual commercial process has been to finish and brighten the surface by polishing or by etching, resulting in a reflection factor of 65 to 75 per cent. But, where either a polished, specular surface or an etched, diffused surface is used, the finish with ordinary aluminum becomes stained when exposed to the weather and is difficult to clean without damaging it.

The new reflecting surface is produced by a double anodic treatment. The first treatment brightens the aluminum, without altering the specular characteristics of the surface. When applied to a highly polished aluminum surface this electrolytic brightening process increases the reflectivity, at the same time leaving on the surface a thin protecting oxide film. The second treatment, identical to the Alumilite process, adds a heavier, wear-resistant oxide coating.



By the new "Alray" process aluminum can be given a surface with a reflectivity nearly equal to that of silver. The surface has a protecting film that is wear resistant and moisture proof



A weather-proof universal motor drives the grindstone through a double-reduction transmission and an overrunning clutch that prevents the grindstone from driving back through the transmission

• Eccentric Bushing for Adjusting Belt Tension

It is not uncommon for a designer to turn from the beaten path and adopt some method which, though more costly as a manufacturing problem is justified when the requirements and results are considered. One such example is found in the design of an internal grinding spindle for application to a standard surface grinder, wherein the usual requirement of an extra idler pulley of either adjustable or spring type was averted by the use of an eccentric bushing.

In the grinding-wheel spindle which was designed and built by Ex-Cell-O Aircraft & Tool Corporation to be applied to a Brown & Sharpe surface grinder, a pulley is mounted on the main spindle. And the grinding spindle which is driven by this pulley through a belt, is mounted on the extending end of a bracket pivoted to the main spindle body which passes through a bushed hole in the grinding wheel spindle bracket. The bushing is eccentric and has a knurled flange by means of which it can be rotated. Rotating this bushing draws the main spindle and the grinding-wheel spindle closer together or thrusts them farther apart, thereby adjusting the tension in the belt connecting the two spindles.

• Motorized Grindstone

Giving a more uniform speed, an electric motor drive for the Fleming grindstone preserves the shape of the wheel and at the same time prevents uneven grinding caused by non-uniform speed. By inclosing the 110-volt universal motor in a bakelite shell the device is made

weather-proof for outdoor service.

The high-speed motor drives the stone at a constant speed of about 60 r.p.m. through a combination spur and worm gear transmission having chrome steel gears and shafts. An auxiliary shaft with a ball thrust bearing carries the worm, relieving the armature shaft of thrust loads.

Because of the high gear ratio the transmission is not reversible. To prevent the heavy wheel from driving back through the transmission when the motor is shut off, an overriding clutch is provided in the wheel axle. This free-wheeling unit also makes it possible to operate the grindstone by hand if necessary, without disconnecting the motor drive.

• Electric Heater for Fuel Oil

A new development to simplify the burning of heavy gravity fuel oil is reported by the Enterprise Oil Burner Company. It consists of an automatically controlled electric heater, a longitudinal cross-section of which is shown here.

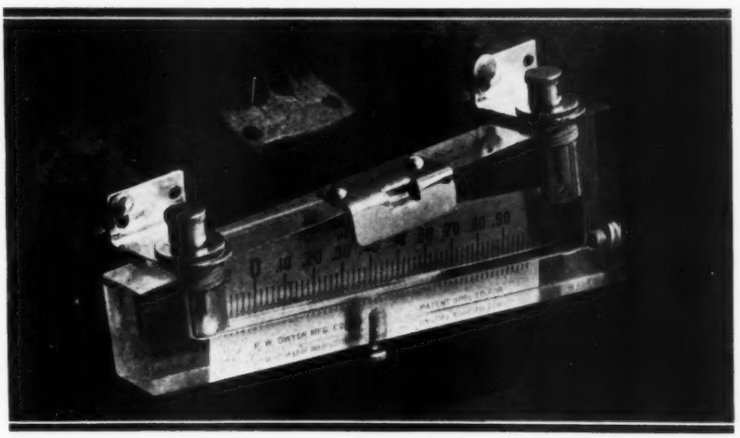
Oil enters the heater under pump pressure, passing below, through and above the heating element before being delivered to the burner. The temperature to which the oil is heated is automatically controlled by the aquastat, which is wired in series with the thermostat of the heating system so that the burner cannot start unless the temperature of the oil has reached the temperature for which the aquastat is set. Also, if for any reason the oil cools off below the predetermined temperature to which the aquastat has been set, the burner automatically stops.

• Safety Control for Lubricating Systems

In machines designed with pressure lubrication, momentary failure caused by a clogged filter, broken oil line or plugged discharge pipe may cause considerable damage to the bearings. A patented electrical control system developed by H. E. Martin and used by Brown & Sharpe automatically stops the machine when the lubricating oil pressure falls below or rises above a predetermined range.

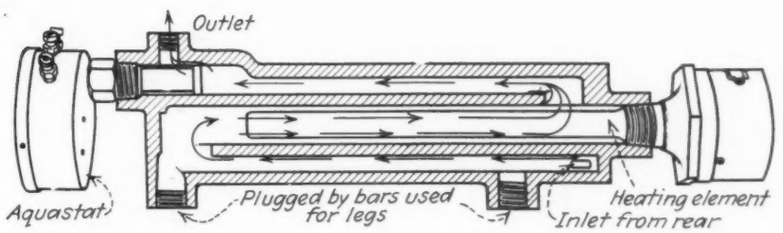
As shown in the accompanying illustration, the control is essentially a pushbutton station, with each of the two buttons operated by a piston moving in a cylinder connected to the pressure side of the oil pump. The upper piston has a heavy spring which yields under excessive oil pressure and opens the contact shutting down the main drive motor. The lower piston having a comparatively weak spring allows the contact to break and stops the machine when the oil pressure drops below a predetermined value. To prevent the oil in the system from draining back into the reservoir when the machine is stopped, a check valve is placed in the line above the automatic control, and is adjusted to maintain sufficient back pressure to hold the low-pressure contact closed.

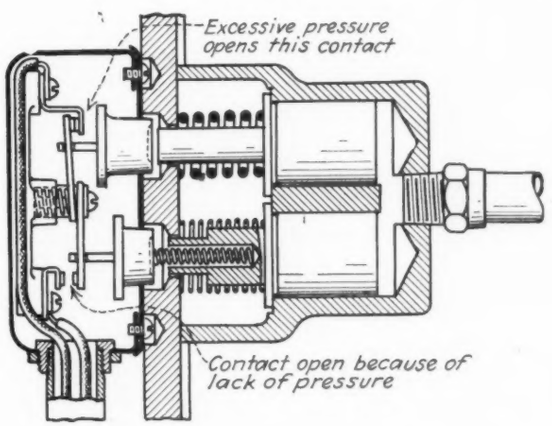
Transparent Bakelite is now used for the inclined tube and chambers of the draft gage manufactured by the F. W. Dwyer Manufacturing Company. The tube and chambers are accurately reamed and since there is no metal casing, all parts are fully visible, making it easier to read the gage



• Spiral Gears for Balancing Thrust

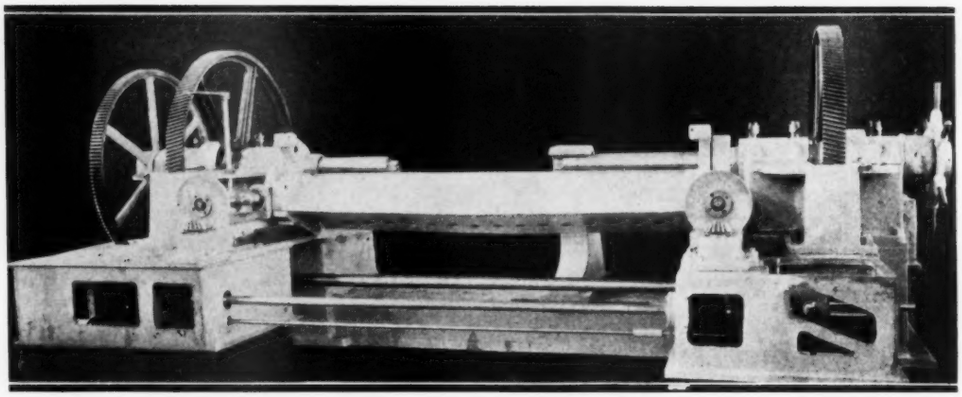
In rotary lathes for cutting wood veneers, helical tooth gears have been found to give the best results





Automatically controlled electric heater developed by the Enterprise Oil Burner Company for preheating heavy oils for combustion in domestic and industrial oil burners

Either excessive oil pressure or low pressure because of lack of oil causes this safety device to shut down the machine



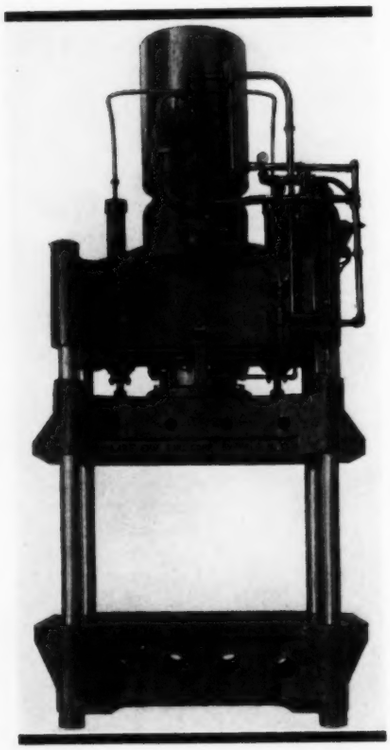
In the veneer lathe of the Merritt Engineering & Sales Company, helical tooth gears are used for the two-fold purpose of smooth running and balancing thrusts

because their smooth operation eliminates chatter and backlash which would have its effect upon the veneer produced.

In the veneer lathe shown here, designed and built by the Merritt Engineering & Sales Company, the accurately cut helical gears serve a second purpose. These large gears develop considerable thrust in operation, and the thrust is used to balance that which comes on the main bearings from chucking a log.

In the accompanying picture the lathe is shown with the gear covers removed. A large spiral gear at each end of the lathe is mounted so that the thrust which it develops is in the direction counter to that created in chucking the log. Thus, as the log begins to revolve against the fixed veneer knife, these two gears automatically take up a goodly portion of the thrust burden and carry it during the cutting operation, thereby relieving the main bearings. A right-hand helical gear is used at one end of the lathe and a left-hand one at the other end.

Other features of this machine are the unit construction, the units consisting of the bed, the head block, the way and slide, the knife and pressure bar, the dogging gear box and the selective gear box. The machine has pushbutton control, ball bearings for the drive shaft and Timken roller bearings for all the other shafts and spindles, including the feed screws.



Self-contained high-speed hydraulic press designed by the Lake Erie Engineering Corporation

• Self-Contained High-Speed Press

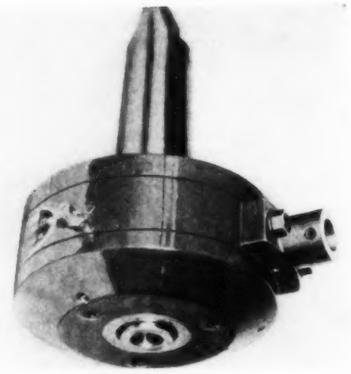
One of the latest developments of the Lake Erie Engineering Corporation is the self-contained high-speed 150-ton hydraulic press. It operates at from 20 to 40 strokes per min., depending on the length of the stroke, which ranges from 18 in. to 60 in. There is 72-in. clearance between columns and the platens are 84x42-in.

The press is equipped with a complete hydraulic power plant, including a direct-connected motor-driven pump, tank, valves and piping. One of the special features is the quick response to the movement of the valve lever. Removing the hand from the operating lever stops the press instantly, the control valve automatically moving to the stop position. In this position the discharge from the pump is by-passed, the pump then working only against the friction head and consuming correspondingly less power. Nor is pump pressure required to hold the press in its upper position.

This feature of by-passing the pump and relieving all pressure on the press is the basic improvement of this design.

• Planetary Drill Speeder Unit

To obtain higher drill speeds when boring small diameter holes, the drill speeder unit shown here,



Planetary gearing with pinions and shafts carried on anti-friction bearings provides a 4:1 speed increase in the Ex-Cell-O drill-speeder unit

designed by the Ex-Cell-O Aircraft & Tool Corporation, provides a 4:1 increase in speed by means of planetary gearing.

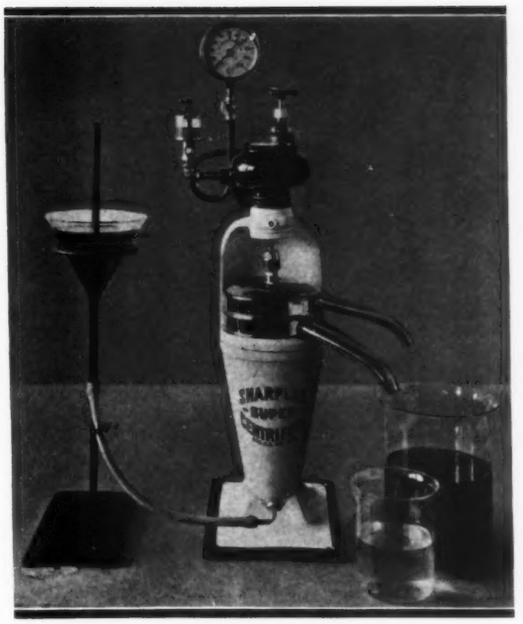
Held stationary by a bar inserted in the boss, the head of the unit carries a ring gear with internal teeth. Three pinion clusters engage with the ring gear and a pinion on the drive shank. A housing carry-

ing the pinion cluster bearings rotates the driven shank at four times the drive shank speed.

Precision roller bearings are used for the cluster pinion bearings, while the drill spindle is carried on precision type ball-thrust bearings. Cluster pinions are of 3120 SAE steel, heat treated; the ring gear is made of heat treated 6145 SAE steel.

• Sharples Super Centrifuge

To provide still higher separating forces for use in sedimentation of solids from liquids and the clarification of liquids, a new laboratory centrifuge, developed by the Sharples Specialty Co., develops a force of 62,000 times the force of gravity. The bowl of the centrifuge is driven by a turbine at a speed of 50,000 r.p.m. and is hung from a spring-supported ball bearing lubricated by a mist of oil. Used oil drains into a well from which it is returned to the bearing after passing through a felt filter. The bowl is a long slender cylinder machined from a billet of forged steel or Monel metal, and is balanced by grinding on the outside.



When operated at 50,000 r.p.m. this centrifuge develops a separating force of 62,000 times the force of gravity, making it possible to accomplish results unobtainable by other methods. Liquid is fed continuously into the bowl through the inlet in the bottom and separated materials discharged at the top

• New Silencing Devices

One of the many new features of the 1934 automobiles is the added attention given to silencing both the intake and exhaust of the engine. The aim of this development has been not only to improve the silencing but also to get away from the old principle of baffle plates and similar obstructions that build up back pressure.

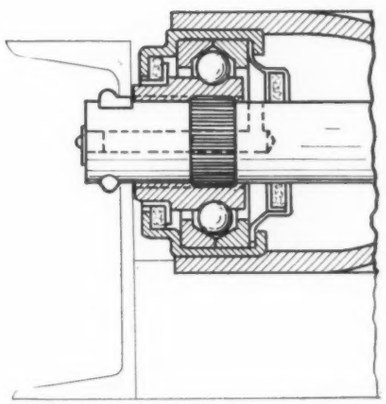
Extended research by the Burgess Battery Company resulted in the type of silencer shown here which is standard equipment on the cars of more than eighteen automobile manufacturers. It is a manifold for either exhaust or intake, in which are incorporated silencing effects ordinarily performed by a separate muffler.

Sound absorption in this manifold is accomplished by means of a porous sound-absorbent material faced with a perforated metal lining through which the gases pass. This lining is perforated in a manner to allow the sound to penetrate freely into the porous-absorbent material without appreciably impeding the flow of the gases. Since no baffle plates or other deflectors are used, there is a minimum of back pressure and little opportunity for the accumulation of soot or carbon, nor are there any pockets for trapping unburned gases that might cause muffler explosions.

Cut-away view of the Burgess silencing manifold for either exhaust or intake. In addition to its use on internal combustion engines, it is adaptable to air compressors, blowers, air hoists and similar machines

• Ball-Bearing Conveyor Rollers

To provide a ball-bearing conveyor roller that can be dismounted readily and also designed to prevent rotation between the ball race and the fixed roller axle, the Mathews "Gearlock" design has serrations on the axle that mate with broached grooves in the inner race. As shown in the accompanying diagram, felt seals are also provided to keep out foreign matter and retain the lubricant in the bearing. Lubricant is supplied through a pressure gun fitting and a drilled channel in the axle.



Ball bearings with their felt seals are removable as a unit. Serrations on the axle prevent rotation of the inner race of the bearing relative to the fixed axle

Each of the two demountable bearings consist of a single row of hardened chrome steel balls carried between outer and inner races of hardened chrome steel and assembled in a heavy pressed steel jacket. A design using eight balls, $\frac{5}{8}$-in. in diameter, in each of the two bearings provides a continuous load capacity of 8,000 lb. per roller.

The upset key at the left end of the axle fits into a slot in the frame preventing rotation and consequent wear at this point.

Discovering Customer Preference

Engineers and other executives of companies manufacturing consumer products tell what they think of the General Motors questionnaire method described in the January number

AT THE request of the editor several chief engineers, two vice-presidents and a superintendent, all of them thoroughly convinced of the need for discovering customer preference, offer in what follows their comments on the method used by General Motors as described in January *Product Engineering*. In addition they explain why they think the method would not apply so well to their respective products, and how they go about getting corresponding information.

In our letter asking for these comments we also asked how far it may be desirable to go in trying to educate customer preference up to the point of accepting a better product than ones to which he has been accustomed. The answers to this question are hardly conclusive, and we therefore propound it for other readers to consider, and to discuss if they see fit.

Useful in Planning

S. M. KINTNER
Vice-President
Westinghouse Electric & Manufacturing Company

● We have used somewhat similar methods in determining certain questions regarding our merchandising items and have found this very useful in planning our designs.

With reference to your second question of how far we should go in attempting to educate a customer to something a little better than or a little different from what he thinks he wants is a question which in my mind is very difficult to answer. I think on the whole it is desirable to do this particularly for the purposes of establishing the value of trade names or company names and thereby getting the customer in the habit of thinking of a particular company as the proper supplier of his needs, as contrasted to the common habit of buying solely on price.

Public Must Be Educated

D. G. SMELLIE
Chief Engineer, The Hoover Company

● We were much interested in receiving a copy of the General Motors questionnaire entitled "The Proving Ground of Public Opinion" when this pamphlet was issued last summer. It is our thought that the solicitation of customer reaction to the current trends of development and design provides the designer with information of great value.

Our company has never used the direct customer contact method. Such investigations in the past have been handled by agencies having suitable distribution of offices. Individual workers operating out of these offices have made personal calls upon customers to obtain the information desired.

Comparing the two methods, we are inclined to favor the method used by General Motors as it eliminates the personal equation of the investigator. It is also more desirable from the customer standpoint as he is not subject to the embarrassment often caused by a visiting representative.

We believe that questions requiring the "Yes-No" type of answer are most desirable, although the successful use thereof requires more care in the formulation of the inquiries which are to be presented to the customer.

With respect to educational campaigns undertaken for the ultimate benefit of the customer, it is our opinion that this is an important step in the development of a new product. This is especially true when a manufacturer is making rapid strides and finds that the improved product differs radically from that which the customer now accepts as satisfactory.

A splendid case in point is the education of the public with respect to the advantages of "streamlined" automotive vehicles and the gradual trend of body styles, culminating as it has in the present Chrysler "air-flow" models. There can be no doubt that the public will show far greater acceptance of the new body styles as a result of this campaign than it would have shown had the new design been presented without the preliminary steps taken during the past two years.

Suggestions from Users

THEODORE H. BEARD
Supervising Engineer, Dictaphone Corporation

● Responding to your specific question, the only experience that I have had with the type of questionnaire put out by General Motors is the answering of that questionnaire. We do try, however, at business shows and at other times, to find out what the user of our machines has to say about them, what his desires are, what he feels should be done to improve our product. We are much influenced by the users' comments. I personally answer every letter that comes into the factory from a user, and I am sure you would be surprised at the number who take sufficient interest in our product to make suggestions for improvement. These are not sent in as complaints by any manner of means, but they are simply offered as little ideas from users on how they believe the machines could be improved.

I am very much interested in customer education. I feel that many of our larger industries have taken backward steps in that regard in the past. In a bus-

iness like our own, where the recording and the reproduction of the human voice for business purposes are the main controlling factors, a real customer educational campaign showing exactly of what recording and reproduction consists, and educating the user in what to listen for and look for in recording and reproduction, would be a definite help.

Discretion Needed

W. E. CRANSTON
Vice-President
Thermador Electrical Manufacturing Company

● Your article "What the Customer Wants" is, I believe, a good way to find out about one's product, providing it is used with a great deal of discretion. I have in mind a feature in one of our products which is a remarkable talking point and very greatly breaks down sales resistance, but which in actual use is of little value. A survey would probably show that the average customer would want this feature eliminated, while the elimination of such a feature would greatly retard sales.

I am glad to see the trend in the getting together of sales departments and manufacturing departments. In most companies, except smaller ones like ourselves, either one of these two departments dominates the other and there is not always the harmony between them which spells efficiency. I think if you would act as you are, as a go-between for these two major functions of product, you will be doing a great work.

Investigations Too Costly

E. A. FARR
Superintendent, Manning-Bowman & Company

● We have never had an elaborate system such as employed by General Motors for determining customer preference because in our case the investigation would be too costly and by the time we received the information the merchandise would be out-moded.

We do make an investigation before we start to design new merchandise, mostly concerning price, but style and design are left entirely to our own stylists.

After we have made hand-made models of our product we conduct an investigation, very largely in New York, going to buyers, sales girls, department heads, etc., for their opinions. Also, prior to this investigation we seek the opinions of local people who we believe have good judgment, and these opinions we find in a great many instances do not vary from our own first impressions. However, we do feel that they are worthwhile if for no other reason than to substantiate our own ideas.

Not Applicable to Buses

H. E. SIMI
Chief Engineer, Twin Coach Company

● I received the questionnaire sent out to the public by General Motors, referred to in your letter of the fifth. I read over most of the questions as a matter of interest for it seemed to be a new and novel way of planning out what the public wants. I was not particularly impressed, however, with this system as being conducive of satisfactory results for, in my estimation, very few of the answers would be based on actual experience and facts. I am under the impression that the average car owner does not know the fundamental requirements of an automobile well enough to make detail recommendations as was requested in their questionnaire.

We have not used this method of determining the customer's preference and we do not believe this system would be applicable to buses, for buses are bought by operators who have had broad experience and are intimately familiar with most of the requirements that are necessary to make the vehicles practical for their purposes. We, as manufacturers, are not infallible and we have noted from time to time that even the operators are prone to ask for a miscellaneous assortment of "nicknacks" that oftentimes complicate, rather than simplify, their equipment.

Suggestions Hard to Get

G. M. PELTZ
Chief Engineer, Motorstokor Corporation

● We have made efforts to determine the preferences of the public but only by interviewing our own customers about six months after a sale. The results of such inquiries have not been particularly satisfactory nor enlightening.

It is our opinion that research methods such as those used by the General Motors Company, while they may be very useful in an industry as thoroughly established as the automobile business, are of little use in an industry as young as ours with which the general public is very little acquainted.

The principal sales effort at the present stage of our industry is to convince the public that our equipment will really fulfill the claims which we make for it and that it is trouble-free and durable. Since the style element has not yet become a factor in this industry and for the most part purchases are made on a dollars-and-cents and a utilitarian basis, we do not feel that such a questionnaire would be of particular value at the present stage of this industry although we can see how it might prove beneficial at some later date.

Unenlightened Customers

P. EDUARD GELDHOF
Chief Engineer, Easy Washing Machine Corporation

● Our sales department, in planning for sales of Easy washers, do not have many of the natural factors to work for us that are encountered in other industries. In the radio and the automobile one has the pleasure appeal, while the washing machine is a device which is usually hidden away in a disagreeable part of the home and is not chosen for its appearance. Furthermore, our customers are not conversant with all the details of a washing machine or an ironer as they are with things they buy for pleasure, eye and comfort appeal.

It is therefore our aim to build into our products extra functions for convenience, ease of operation, simplicity and durability so that a good salesman and demonstrator can point out these functions and things to a prospective buyer. That is where we accomplish the most against competition.

STRESS CONCENTRATION
Produced by Holes and Notches

This hitherto unpublished paper was presented at the 1933 Annual Meeting of the A.S.M.E. It describes photo-elastic tests and strain measurements to determine stress concentration more accurately than has been done heretofore, a more accurate extrapolation method being employed

A. M. WAHL and R. BEEUWKES
Research Laboratories
Westinghouse Electric & Manufacturing Company

BECAUSE of the importance in machine design of tension or compression members having holes and notches, the problem of the stress concentration effects produced by such discontinuities is of practical interest. This is especially true where fatigue conditions are involved since it is well known that in such cases the endurance strength is markedly lowered by "stress raisers" even though the material be quite ductile. For this reason the problem has been receiving considerable attention in recent years.

The investigation reported in this paper is concerned primarily with the cases shown in Fig. 1, the problem being to determine the stress concentration facor K for various values of d/W, this being the ratio of the diameter of the hole or notch to the width of the bar. The factor K is herein defined as the ratio of the maximum stress to the average stress in the minimum section. Such information is particularly useful in connection with fatigue tests on grooved specimens or specimens having transverse holes, as well as in the design of machine members with such discontinuities.

While the cases represented in Fig. 1 have been studied by previous investigators, notably Coker and Preuss, it was felt that the accuracy of the methods used by these investigators could be improved by using the photo-elastic fringe method as developed by Tuzi, Frocht, Baud, Solakian and Karelitz. After the pres-

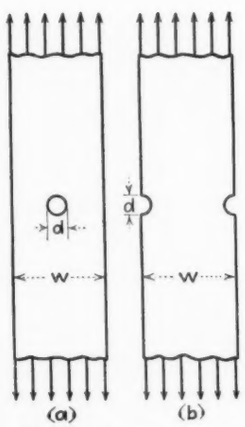


Fig. 1—Stress concentration factor K, the ratio of maximum to average stress in the minimum section, is determined for various values of d/W

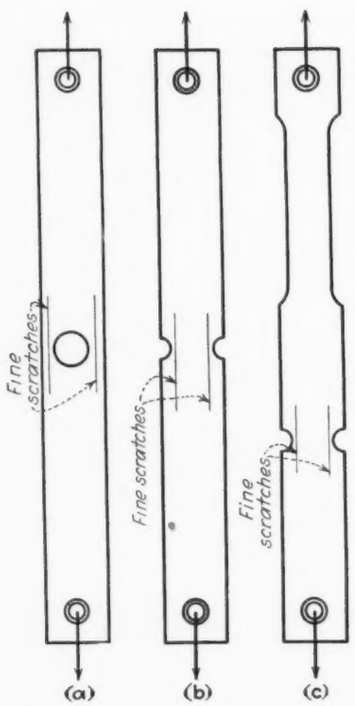


Fig. 2—Various types of test specimens used. The maximum stress at the edge of the specimen was obtained from the photographs by plotting the fringe order against distance from the scratch mark

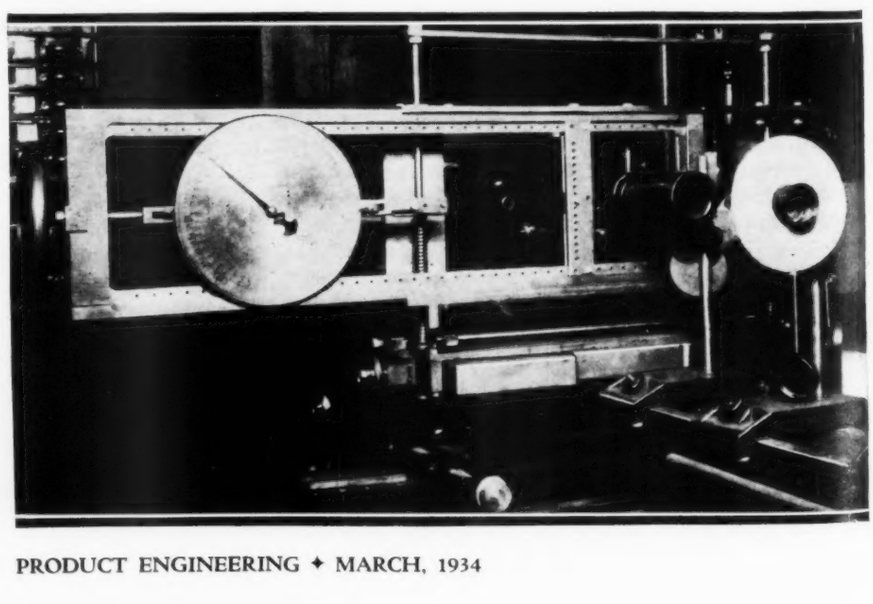


Fig. 3—Bakelite specimen mounted in the loading frame of the testing machine, showing the scale used to determine the load

ent investigation had been practically completed a paper by A. Hennig appeared in *Forschung* (Vol. 4, No. 2) covering the case of Fig. 1(a). The results given in that paper agree well with the present tests, except for values of d/W that are close to unity. The test method described in this paper consists essentially of making bakelite specimens having holes or notches of the correct size, loading these in a loading frame in the photo-elastic apparatus, passing monochromatic light through the specimen, and taking photographs of the black and white fringes thus produced.

Test Specimens

Sketches of the various types of test specimens used are shown in Fig. 2. A view of a bakelite specimen in the loading frame is shown in Fig. 3. The scale used to determine the load is also shown.

Typical fringe photographs made in this manner are shown in Fig. 5. Each fringe represents a definite value of principal stress difference in the body of the specimen, while at the edge each fringe represents a definite value of stress which may be determined by

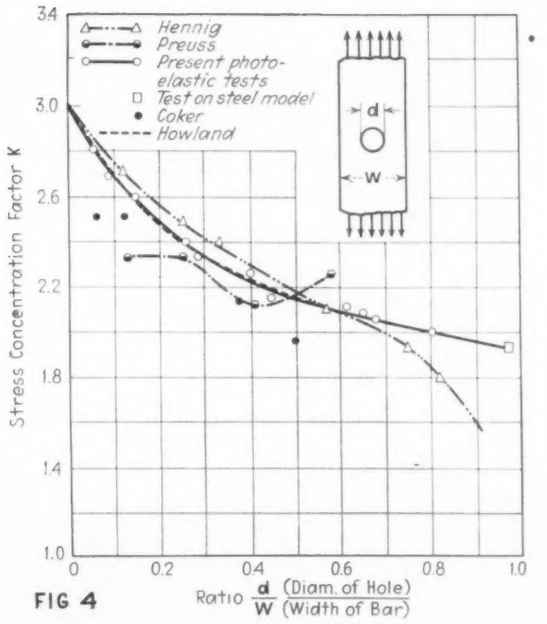


Fig. 4—Curves of stress concentration factor K plotted against the ratio d/W for bars with holes, as determined by the present tests and other investigations

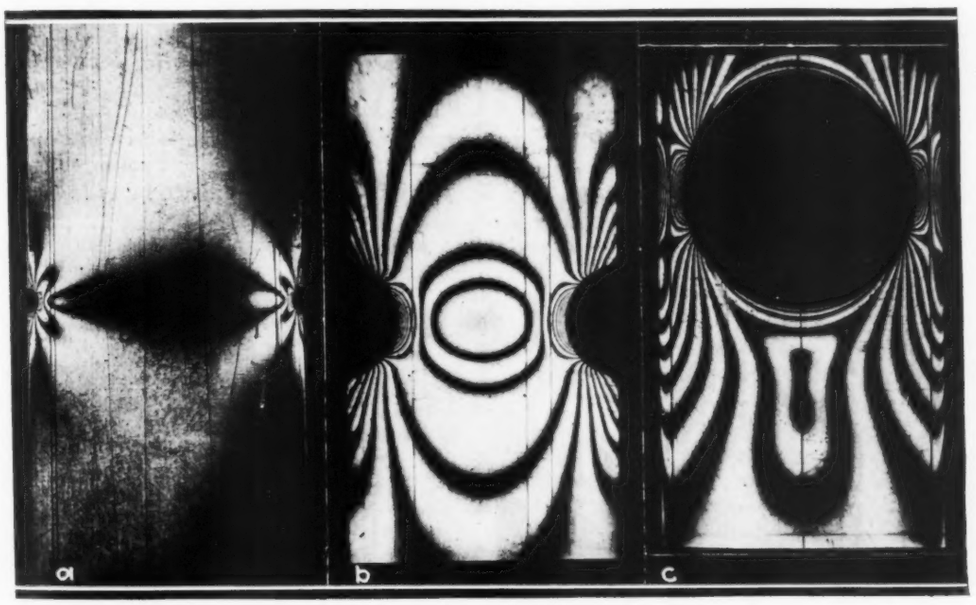


Fig. 5 — Typical fringe photographs made in the tests described here. At *a* and *b* are semi-circular notched specimens and at *c* is shown the effect of a large hole. The scratch lines were used in determining the maximum stress at the edge of the bar

calibration, using the uniformly stressed portion of the specimens shown in Fig. 2. In all cases the relation between fringe order and stress was found to be practically linear.

In preparing the bakelite specimens, the final machining cuts were made after annealing the specimen to remove internal stresses. This was done to avoid undesirable edge effects. For the same reason it was also found necessary to use extremely light cuts in the final machining because such edge effects would make it difficult to determine the maximum stress.

Test Results and Discussion

In obtaining from the photographs the maximum stress at the edge of the specimen, the fringe order was plotted against distance from the scratch marks shown in Fig. 2. A microscope or comparator was used to make these measurements. This curve was then extrapolated to the true edge of the specimen. The distance from the scratch marks to the true edge on the photograph had to be determined from an actual measurement of the specimen and the known magnification of the apparatus, since the edge of the specimen was not defined sharply enough on the pictures.

The results of the present tests on bars with holes are represented by the small circles of Fig. 4, which indicate values of the stress concentration factor K plotted against the ratio d/W. The black dots and half-filled circles represent values calculated from previous tests by Coker and Preuss, which tests were reported in the *Proceedings of London Physical Society*, 1912-13, p. 95, and in *Forschungsarbeiten* No. 126, 1912, and No. 134, 1913. The small triangles indicate values calculated from tests by Hennig, while the

dotted curve represents the mathematical results obtained by Howland published in the *Philosophical Transaction of the Royal Society,* A 1929, p. 49. It will be seen that there is good agreement between the present tests and the results of Howland and Hennig for ratios d/W less than about 0.5. At ratios near unity there is some difference between the present results, which tend to approach a value not far from 2, and those of Hennig. The small square for a ratio $d/W = 0.97$ represents a test on a steel model as will be described.

The results of the tests on bars with semi-circular notches are plotted in Fig. 6. Here again the small circles represent the present test results, the black dots those of Coker and the half-filled circles those of Preuss. As in the case of the bar with the hole, the present results are in general higher than those of previous investigators, which may be explained by the fact that these investigators used the photo-elastic compensation and strain gage methods, both of which are particularly difficult to apply near a localized point of maximum stress.

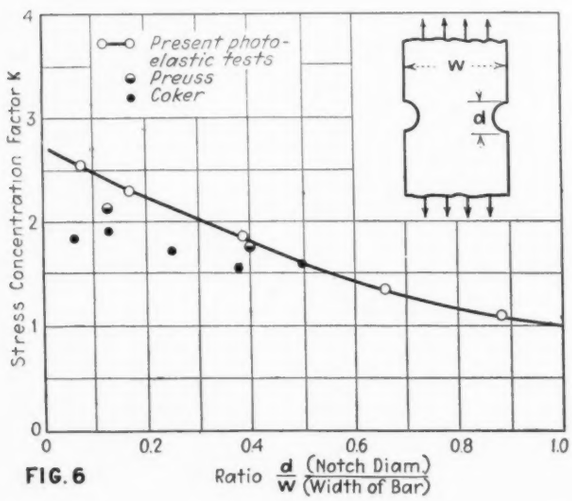


FIG. 6

Fig. 6 — Curve for stress concentration factor *K* for bars with semi-circular notches based on the results of the tests described here. As is to be expected, the stress concentration approaches unity as the ratio d/W approaches unity

It will be noted that the curve in Fig. 6 approaches unity for ratios d/w near unity, as is to be expected.

Tests on Steel Model

To find out what happens when the hole diameter approaches the width of the bar, a steel model was designed, as shown in Fig. 7, having a ratio of $d/W = 0.97$ ($d = 4$ in., $W = 4\frac{1}{8}$ in.). Extensometers were clamped both on the outside, as in Fig. 7, and on the edge of the hole, as indicated in Fig. 8. The stresses thus measured were 28,100 lb. per sq.in. on the inside and only 1,400 lb. per sq.in. on the outside, giving a stress distribution as shown. This is rather contrary to what one would expect for such a thin section, the natural expectation being a more or less uniform stress distribution. The results of this test, as mentioned previously, are represented by the small square in Fig. 4.

Formulas for Calculating Stress Concentration Factor

To calculate the stress concentration factor K, the following empirical formulas, which agree well with the test results, may be used.

For the bar with the hole, Fig. 1(a):

$$K = 3 - \frac{3.13d}{W} + 3.76\left(\frac{d}{W}\right)^2 - 1.71\left(\frac{d}{W}\right)^3$$

In this equation, K equals the ratio of the maximum stress to the average stress in the minimum section, and d/W is the ratio of the hole diameter to the width of the bar.

For the bar with notches and loaded, as shown in Fig. 1(b):

$$K = 2.75 - 2.75\ \frac{d}{W} + 0.32\left(\frac{d}{W}\right)^2 + 0.68\left(\frac{d}{W}\right)^3$$

In this equation, d/W is the ratio of the notch diameter to the width of the bar.

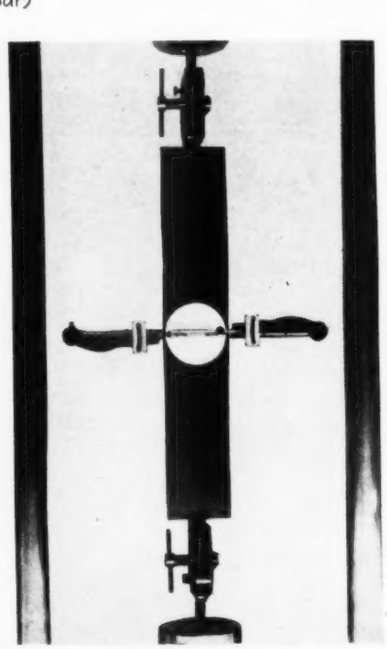


Fig. 7 (Right)—Test set-up of a thin steel bar with a circular hole wherein $d/W = 0.97$ and the stresses were measured by extensometers. The results of this test are shown by the small square in Fig. 4

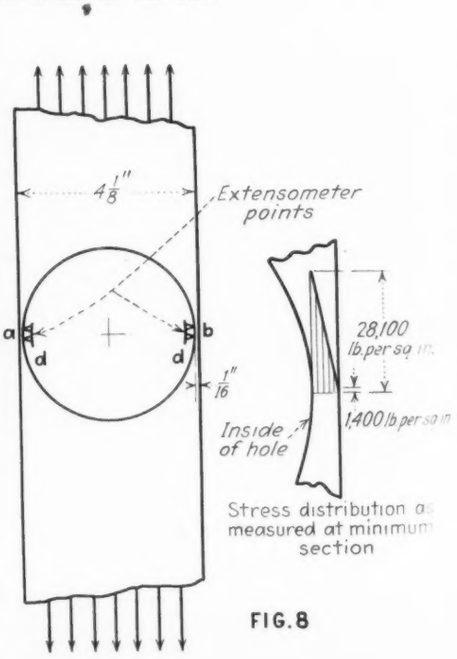
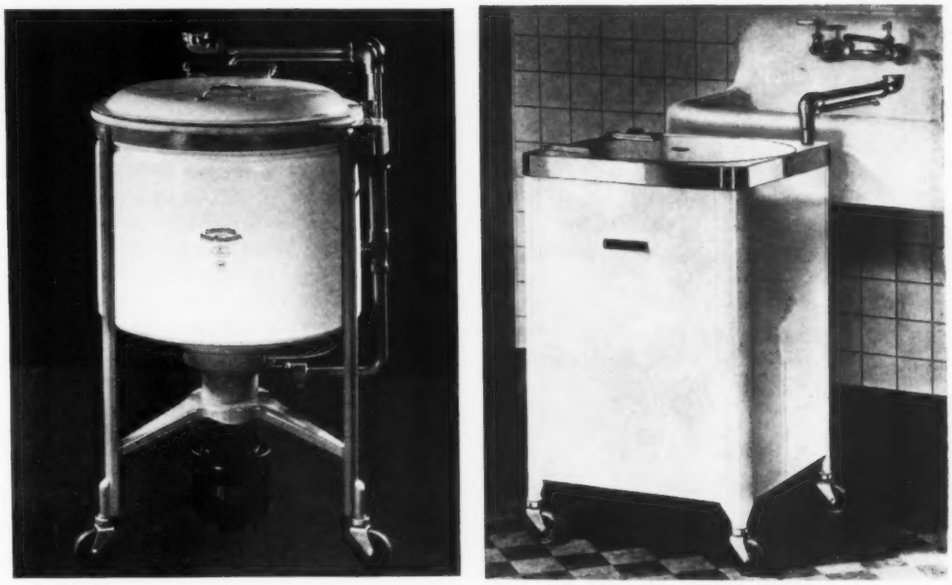


FIG. 8

Fig. 8—In the test set-up shown in Fig. 7, extensometers were also clamped on the edge of the hole as shown here. The tests gave a stress of 28,100 lb. per sq.in. on the inside of the hole and only 1,400 lb. per sq.in. on the outside



Both the old round model and the new square model Conover dishwashers have the same capacity and operating features. Although the new model is heavier, the ball-bearing rubber-tired casters make this additional weight scarcely noticed when moving the machine. The square shape and skirt not only improves the appearance, but also increases the utility of this dishwasher

Case Histories In Product Design—IX

T. J. MALONEY
New Jersey Zinc Company

BOTH of the household machines described here are featured by the many mechanical improvements with reference to the details of their design, in addition to the striking changes that have been made in the appearance of the product. These mechanical improvements relate primarily to details contributing to improved functioning of the machine and simplification of its operation. Both show the results of a careful study of consumer requirements and indicate that much thought was given to the problem of harmonizing the appearance of the product with modern trends.

Conover Electric Dishwasher

Case History No. 25

Designed by the Engineering Division of the Conover Company, this dishwasher shows the result of a development wherein the primary purpose was to create a new model that would conform to the accepted shape for modern kitchen equipment.

Design Aims—To keep abreast of the trend toward the unit electric kitchen, the Conover Company decided to develop a new model of their dishwasher which was to be square instead of the former circular shape. Although this proved to be the most striking change in this new model, as can be seen from the accompanying pictures, numerous detail refinements were made in order to simplify operation and further improve the durability of the machine.

Design and Manufacture—The new square Model F-4 has the same capacity as its predecessor, the circular shaped Model B. But because of its shape and the added skirt, the Model F-4 weighs 45 lb. more. This, however, is no great disadvantage because the machine is mounted on ball-bearing rubber-tired Bassick casters so that one cannot readily notice the increased weight when moving the machine across the floor.

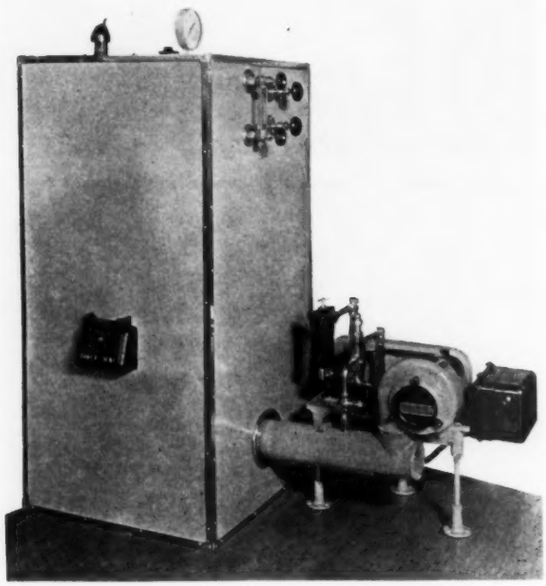
As finally developed, the new model has the same capacity as the old one, namely, 55 dishes and 40 pieces of silver. The finishes of both models are white porcelain enamel and satin finished chrome plating. The dish racks are of rubber-coated iron or lacquered Everdur.

A $\frac{1}{4}$-hp., 1,700 r.p.m. motor drives directly an aluminum-bronze chromium-plated impeller at the bottom of the tub. In the operation of the machine, the racks remain stationary and the impeller throws the water with great force against the dishes. Chromium

plating of this impeller is a new feature primarily for the purpose of reducing pitting and erosion. Also, the chromium finish makes it easier to keep the surfaces of the impeller clean.

For filling and draining the dishwasher, a swinging combination intake and outlet pipe, adjustable as to height and horizontal length, makes it easy to swing this pipe under the spigot. The motor is turned on before filling the machine, and when the correct amount of water, $5\frac{1}{2}$ quarts, has been put in the machine, any excess is automatically discharged through the outlet pipe, thereby automatically controlling the amount of water in the machine.

Drainage is through a rotary sleeve-type valve in the bottom of the tub, the water being forced out by a centrifugal pump. The rotary sleeve valve is operated by a flexible wire which connects it to a conveniently located control at the top of the machine. Both the motor and drain control are operated by a single dial master control.



In the previous model of the May oil burner, the various units were placed at the most convenient positions with emphasis on accessibility and efficiency of performance

Illustrative of the attention that was given to the details, the elbow between the vertical and horizontal section of the combination intake and discharge was made about 95 deg., instead of a right angle. This was to compensate for the unavoidable sagging of the horizontal pipe. Another feature is the heavy rubber-covered flexible cord with soft rubber plug having a long hand grip extension. Like all of the other details of the machine, its apparent high quality and durability bespeaks a high quality product.

Sales Success—In spite of fact that the new square-shaped model sells for $40 more than the circular model, its early sales record came up to expectation. In the New York market, the new model actually outsold its lower-priced friendly competitor. Possibly a change in merchandising plans, and the greatly improved electrical goods sales in 1933 partly account for a sales increase of 75 per cent for both machines. Because this new model is characteristically a built-in equipment, it is not expected that the sales will find their level until there is renewed activity in the building of apartments and residences. On the other hand, with apartment renting in a chaotic condition, there is a possible market in installing dishwashers in existing apartments as a sales point to procure tenants. And with space at a greater premium in apartments than in the average home, the square model will undoubtedly be favored.

Probable Reason for Success—All the reasons for success can be summed up in an appreciation of the market of such a product. It started ahead of competition and recognized a definite style trend, fitting the design to the need of today and the immediate future. But, in addition to all this, the evident attention that has been given to the design of this product to make it one of high quality in all its details is undoubtedly a great influencing factor in its successful merchandising.

Quiet May Oil Burner

Case History No. 26

The mechanical design of this product was developed by the engineering department of the May Oil Burner Corporation, while the appearance phase of the design was handled by Lurelle Guild. Perhaps the most unusual feature of this development is that the appearance problem was almost entirely divorced from that of the mechanical design.

Design Aims—In addition to their desire to make improvements in the mechanical design of their oil burner, the May Oil Burner engineers were conscious of the fact that with the elimination of the old coal bins and the dust and dirt associated with coal burning, the cellar is usually renovated to serve as a play room or bar room. Therefore, it was concluded that an attractive appearance of their burner would be a strong sales talking point.

Design and Manufacture—An excellent idea of the problem in mechanical design that confronted the engineers can be obtained from the accompanying picture of the old model. The various units that comprise the burner were placed at what were considered to be the most convenient positions. Thus, in order to make the strainer and pressure regulating valve most accessible, they were elevatd relative to the other units. As shown in the picture, the oil pump was driven by a V-belt, and the electrical controls were overhung on the base at the front of the machine.

It is self-evident that in the old design little emphasis was placed on either style or functional appearance and greatest importance was attached to "practical requirements." This is borne out by such factors as accessibility of the strainer to simplify the operation of cleaning it when necessary and the placement of the electrical controls where they would be most accessible. From a mechanical standpoint this model represents a high-grade engineering accomplishment with reference to

dependability of operation, efficiency, and durability of the product. One of its outstanding features was the use of a sapphire jewel for the oil nozzle.

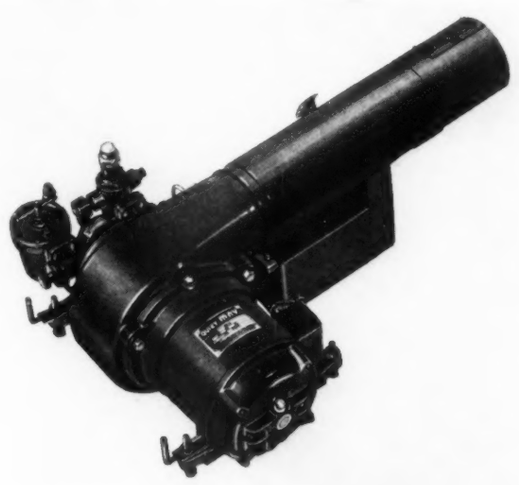
In order to improve the appearance of this product, the engineers were confronted with the problem of developing a more compact machine. A study of the old design made it evident that there were several ways in which greater compactness could be procured.

It will be noted that in the old design the oil pump is driven by a V-belt. It was quickly realized that if the oil pumps were driven directly by extending the motor shaft beyond the blower instead of driving the pump by a V-belt, it would be possible to position this unit in closer proximity to the motor fan. This would also pave the way for relocating the strainer and pressure regulating valve. How this apparently simple change affected the whole design is shown by the picture of the mechanical parts of the new model of the oil burner with the hood removed.

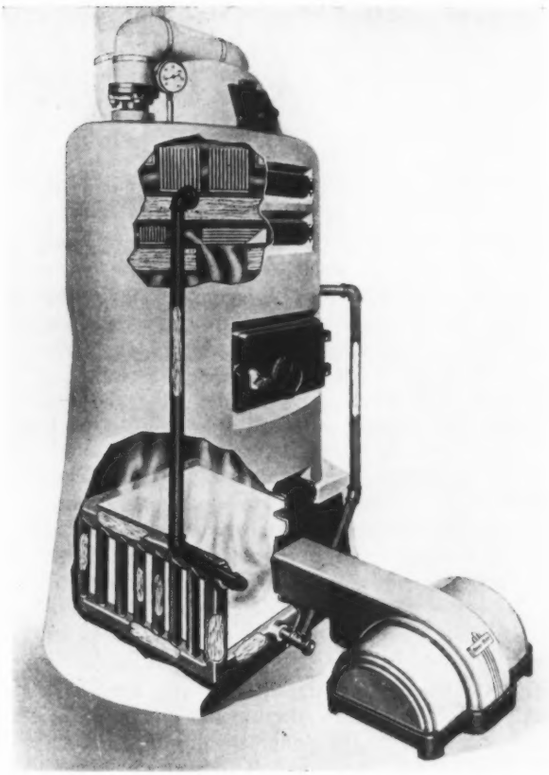
In order to balance the unit, the strainer, pump and the pressure regulating valve were placed on the side of the blower opposite the $\frac{1}{8}$ hp. split-phase Century motor. This immediately created the problem of isolating any vibrations that might develop in either the motor, blower or pump, which was solved by putting flexible joints in the shaft at three separate points. Not only did this have the desired effect of eliminating the possibility of vibrations and noise, but it also prevented any binding action in the shaft at the bearings, which would cause excessive wear.

The second line of attack was to decrease the height of the unit. This was done by putting the mechanism below the center line of the wind pipe instead of above, as in the old model. Not only was space saved, but it also resulted in a better sweep from the fan housing into the wind pipe.

It will be noticed that with reference to accessibility, no sacrifices have been made. The space below the wind pipe is used for mounting the transformer that furnishes the high-tension spark for the ignition. No change was made in the design of any of the units so that there was a minimum of re-tooling involved.



A simple rearrangement resulted in an extremely compact unit with fewer parts. One improvement was in the use of sapphires for the atomizer and orifice of the nozzle



The hood of the May oil burner has no functional purpose, it is solely for hiding the mechanical units and giving the product a graceful appearance

The whole burner mechanism is mounted on a cast-iron frame the feet of which can be seen in the picture extending out from below the motor. Standard bolts are used for the leveling legs. Approximately in the center of the cast-iron base is a shear rubber mounting unit which supports the burner at about its center of gravity. This rubber mounting isolates the vibrations that might create noises.

One distinctive improvement in the details of the design is the burner nozzle orifice. In the previous model this orifice was a natural sapphire orifice with a hardened tool steel nozzle plate for atomizing the oil. In this new model, however, both the atomizer and the orifice are made of natural sapphire, thus giving a unit that is entirely resistant to wear and acid corrosion.

With all of the units of this mechanism arranged compactly, Lurelle Guild, prominent industrial stylist, was commissioned to give the product a smart and graceful appearance. Mr. Guild solved his problem by simply putting the burner mechanism in a permanent package, namely a hood. The color schemes include a choice of orange, red, blue, green and black, all with glossy finish and chromium trim.

Sales Success—Because this product has just been introduced on the market, it is impossible at this time to give any figures relative to sales success. The product received an enthusiastic reception when it was first presented to the public at a preview on February 3 at the Waldorf-Astoria Hotel, in New York. It also attracted great attention at the Heating and Ventilating Exposition recently held in New York.

One-Piece Electrical Contact

With the silver or platinum contact metal fused to the base metal, the rate of heat conduction away from the contact is increased, thereby improving the performance and increasing the life of the contact. Usually, such contacts are also less expensive

FAILURE of electrical contacts is usually caused by the heat generated by the electric arc which occurs when the contact is opened. Unless the heat is dissipated by conduction or otherwise, the resulting high temperature will damage the contact surfaces or perhaps even fuse the contacts together. Pitting of the contacs will decrease the contact area and increase the resistance across the contact, thereby increasing the tendency to further overheating.

When a silver or platinum contact is made as a separate piece and riveted to a base-metal support, the boundary surfaces between the contact and the support will hinder the flow of heat. This will contribute to increasing the temperature of the precious metal contact. Intimate contact between the precious metal and the base-metal support can be had when the silver or platinum contact metal is fused to the base metal, thereby greatly increasing the rate of heat conduction and improving the performance and life of the contact.

Any thickness of silver or platinum can be obtained on any thickness of base metal. The precious metal need only be heavy enough to take care of mechanical wear while the base metal takes care of heat absorption and provides the required mechanical strength. Various forms of laminated and striped metals are shown in the accompanying illustrations, Figs. 1, 2 and 3.

For maximum economy, the contact blanks should be as small as possible with reference to both the dimensions of the precious metal and the over-all width, length and thickness of the contact. The blanking and layout should be planned so as to keep the amount of scrap to a minimum and all the precious metal scrap should be recovered and sent to the refiner, its scrap value usually being worth an appreciable amount.

In striped material, the precious metal must necessarily run lengthwise with the grain. Practically any width, thickness, placement or number of stripes can be supplied on copper, brass, bronze, monel metal or beryllium copper. With silver at its present level of 45 cents to 50 cents per troy ounce, the cross-sectional area of the silver eliminated must be at least 10 per cent of the total cross-sectional area of the combined metals before the striped metal becomes more economical than the completely covered strip. Also, it is not generally economical to use striped silver contact material unless the quantity ordered is at least 10 pounds. The smallest quantity of whole-covered material that can be made at one time is not less than 2 pounds of strip, 5 pounds of wire, or 1 pound of tubing.

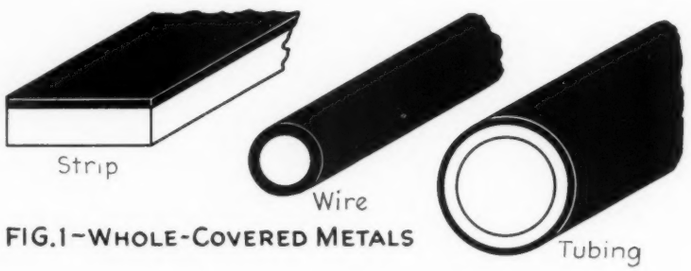


FIG. 1 – WHOLE-COVERED METALS

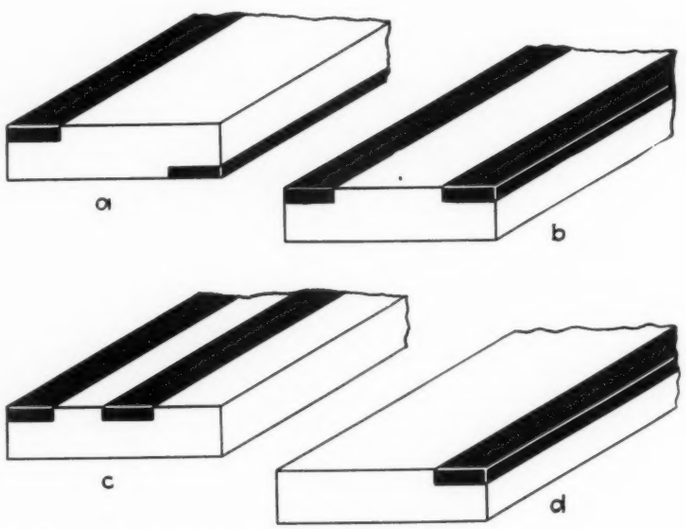


FIG. 2 – STRIPED METALS

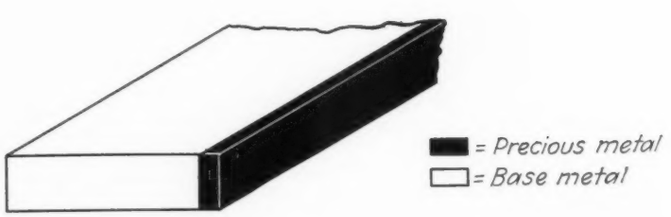


FIG. 3 – SOLID EDGE METAL

Units of Laminated Metal

GEORGE A. RUEHMLING
General Plate Company

FIG. 4 - BRACKET CONTACT

FIG. 5 - BRIDGING CONTACT

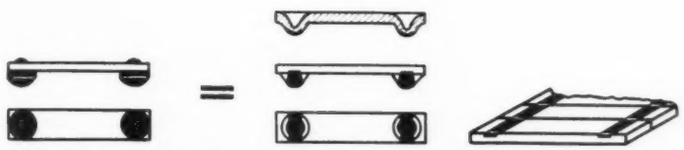


FIG. 6 - HEAVY-DUTY BRIDGING CONTACT

FIG 7 - SMALL CONTACT AND SPRING

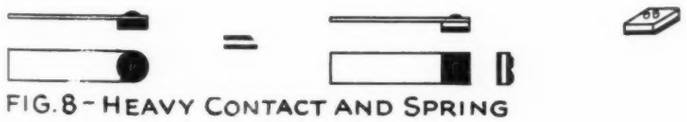


FIG. 8 - HEAVY CONTACT AND SPRING

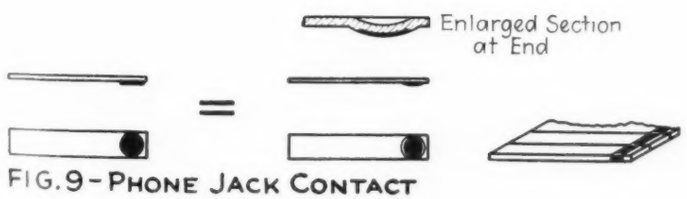


FIG. 9 - PHONE JACK CONTACT

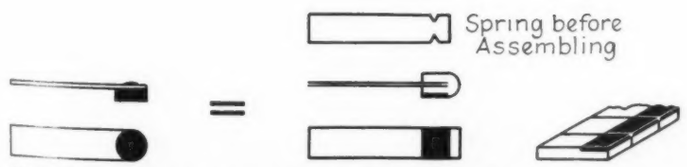


FIG. 10 - HEAVY CONTACT AND SPRING

Fig. 4—A common type of stationary contact made from the type of material as shown to the right, this material being similar to that shown in Fig. *2d*. In the development from the two-piece contact to the one-piece contact, the over-all height of the bracket has been reduced, thereby making possible a smaller assembly.

Fig. 5—This is the usual three-piece rivet assembly bridging contact which has been redesigned as a one-piece unit. The rounded ends have been retained. This does not involve any great waste as the silver-covered scrap resulting from the trimming can be salvaged.

Fig. 6—The development of this heavy-duty bridging contact from the riveted to the one-piece construction shows the extent to which striped material can be formed without causing the separation of the component metals at the seams. In forming the buttons, the silver stripes are widened by stretching with a consequent thinning of the precious metal. A seam should never be located on the outside corner of a 90-deg. bend.

Fig. 7—In this design is shown how a small silver rivet and bronze strip spring can often be replaced economically with a one-piece laminated strip composed of a silver veneer on one face of spring bronze.

Fig. 8—Where considerable heat is generated in the make-and-break, it is frequently necessary to have a large bulky contact on a thin spring blade. By using a stamped double-posted contact made of whole-covered metal, it is possible to obtain considerable bulk without excessive cost.

Fig. 9—Some contact applications require platinum which must be used sparingly. The whole-covered strip would be much more expensive in the form of a long spring blade than a two-piece spot-welded unit. To obtain the benefit of striped material it is necessary to use beryllium copper to retain good spring properties. The blades are chopped diagonally or at right angles to the grain from platinum-striped beryllium copper. The finished pieces are annealed to remove directional properties and to give the metal a uniform and equi-axed grain structure. The blanks are then given an age-hardening treatment to impart the required spring temper.

Fig. 10—This is an alternative to the design given in Fig. 8. Striped metal strip is folded over one end on the spring blade and then stamped. The nicks on the edges of the blade will prevent the parts from separating and will insure a snug and secure fit.

Types of Jewel Bearings and Their Mountings

Engineering data on the design of light-duty bearings for long wear and minimum friction, such as used in instruments, meters and scales

We are indebted to The John Worley Jewel Company, Aurele M. Gatti, Inc., and The Swiss Jewel Company for the information on jewel material and manufacturing processes

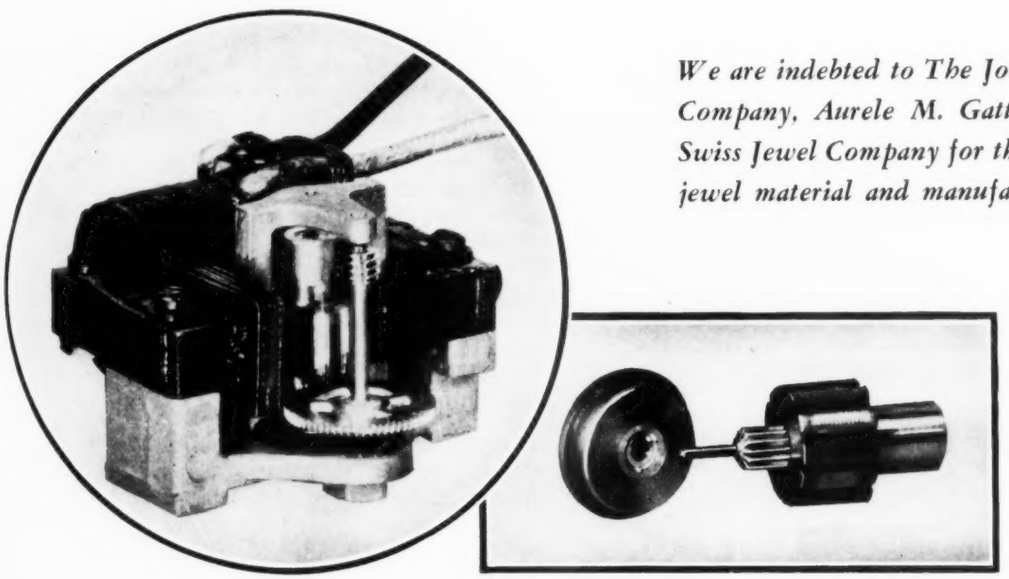


Fig. 1 — Sapphire jewels are used for the rotor shaft to carry radial load, and for the worm shaft to take worm thrust in this small Westinghouse timing motor. Rotor assembly and lower jewel bearing are shown enlarged

WITH increasing precision and sensitivity required in many of the modern commercial instruments such as electric meters, speedometers, pressure gages and weighing devices, the jewel bearing is coming into much wider use. No other bearing has such a low frictional drag and extremely high wear resistance as the jewel type, especially under conditions of poor lubrication. In fact, jewel bearings are the only kind that can be used to carry loads without lubrication. Properly designed and mounted, these bearings can be expected to operate satisfactorily over a period of several years with but little or no attention. For example, sapphire bearings for the rotating disk in watt-hour meters have been found to be in perfect condition after more than twenty years in continuous service without any attention.

Four principal factors influence the friction and life of jewel bearings: (1) the form of the bearing, (2) the bearing material, (3) the pivot or journal material, (4) the bearing size.

Of the two general types of these bearings, one using a hole jewel and the other a V-jewel, the former has the greater load capacity, but its frictional drag is much greater than in the pivot or V-jewel type. In addition, side play or diametral clearance is inherently less with the hole type than the V-jewel. This is important in many bearing applications such as in gear trains, for example.

The hole jewel bearing is ordinarily used to carry only radial loads. Because of its large bearing surface the plain hole bearing shown in Fig. 2(a) has low unit bearing pressures, giving this bearing the principal advantage of long wear. Although hole jewels are generally used only for radial loads, these bearings can be designed to carry a limited thrust load, such as the weight of a vertical shaft assembly. For such a design a shoulder cut on the shaft, bearing against the polished face of the jewel, will support some thrust; but if the thrust loads are appreciable a special bearing design, shown later, must be used. Frictional drag in a plain hole jewel bearing is but little less than that in a bearing using a bronze bushing, but the life of the jewel bearing, particularly under conditions of poor lubrication, is much longer because of its greater wear resistance.

For hole jewel bearings having a minimum friction and for moderate radial loads, the "olive" hole jewel shown in Fig. 2(b) is used. This type of bearing has a much smaller area of contact and, therefore, less frictional drag than the plain hole bearing. However, because of its reduced bearing area the load carrying capacity of the olive type is correspondingly less than that

of the cylindrical hole jewel, and is more liable to be damaged by shock loads. Only a light axial or thrust load can be carried on the thrust area of the olive type jewel without greatly increasing frictional drag. For registers, dial gages, watches and clocks where the radial loads are small and the thrust loads are virtually absent this bearing is used extensively.

For heavy thrust loads such as are present in a heavy vertical shaft or worm drive, an additional jewel bearing as shown in Fig. 3(a) is used to take all the thrust loads, leaving only radial loads to be carried by the hole jewel. As in the hole jewel design, the type of thrust bearing to be used depends on the allowable bearing friction. For light thrust loads where friction is not an important consideration, a hardened steel plate bearing against the flat end of the journal may be suitable. In some weighing devices where thrust bearings are used merely to keep the knife edge bearing in position, the hardened steel shaft extension is ground to a sharp point as shown in Fig. 3(b), and bears against a hardened steel plate. For minimum drag under heavier loads, the end of the journal is given a radius at the point of contact with the jewel thrust plate or "end-stone." As the contact area is reduced by using a smaller radius on the end of the journal in order to reduce friction, the unit pressure increases, making it necessary to select bearing material that is more durable—and usually more expensive.

For maximum bearing life, which increases with reduced unit pressures, large journal diameters are necessary, but the cost of the jewel imposes a practical limitation on the diameter of the journal. Because of scarcity, larger jewels cost much more in proportion to size than small ones. For example jewels with a hole diameter of about 0.02 to 0.03 in. cost only a few cents each in quantities, and in this range of sizes the price is but little affected by the diameter of the jewel since, as shown later, the manufacturing expense is the largest element in the cost. With a hole diameter of 1/4 in. a jewel may cost as much as several dollars, the price depending for the most part on the jewel material.

In the selection of the journal material, the most important consideration is to use a hard material that can be given a high polish. Designs using a plain hole bearing, Fig. 2(a), require steel shafts, either cold-rolled, hardened high-carbon, or stainless steel. Where a brass or aluminum shaft is desirable, polished hardened-steel pins are inserted into counterbores in the ends of the shaft, these pins being used as the bearing journals. For the olive hole jewels shown in Fig. 2(b) inserted pins of hardened tool-steel or music wire are necessary when one or the other of these materials is not used for the shaft. To obtain the low friction and long life with the small area of contact in the olive bearing, the journal surface must be given the best possible polish, microscopic inspection usually being necessary to determine the quality of this finish. Similarly, for thrust bearings carrying a concentrated load at the point of contact with the end-stone, a hard, tough and highly polished pin is inserted in the shaft if the shaft material itself is not sufficiently hard.

Jewel materials suitable for bearings, listed in the order of increasing hardness, are: agate, garnet, synthetic and natural sapphire, ruby, and diamond. The same order also applies to increasing cost and scarcity. Agates, readily obtainable in larger sizes, are less expensive, but because of lack of hardness agates, and garnets as well, are suitable only for plain hole bearings for relatively light loads. Agate bearings of the kind shown in Fig. 2(a) cost only a few cents each for hole diameters of about 1/16 in., and can be obtained in larger sizes at reasonable cost. Garnet is somewhat more expensive than agate, particularly in larger sizes.

Sapphire, either natural or synthetic, is the most satis-

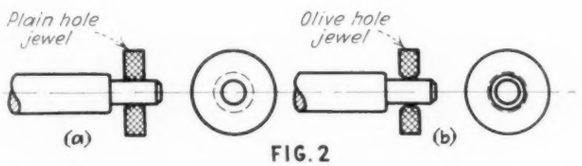


FIG. 2

Fig. 2—Using the same journal, the plain hole jewel shown at (a) has high radial load capacity, while the "olive" jewel shown at (b) is used to minimize friction

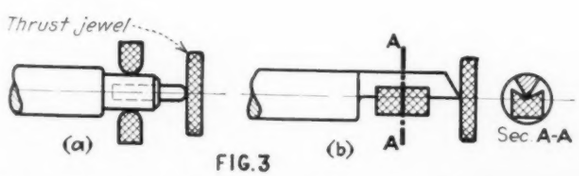


FIG. 3

Fig. 3 — When thrust loads are present, "end-stones" are used with hole jewels shown at (a) and knife-edge bearings shown at (b) since these bearings can take no thrust load without greatly increasing the frictional drag

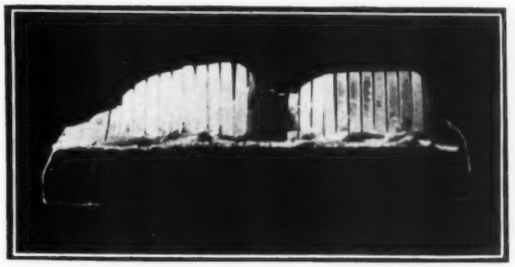


Fig. 4—In the manufacturing process used by the Swiss Jewel Company the synthetic sapphire "boule" is split and cut into plates of the proper thickness for the jewel bearing

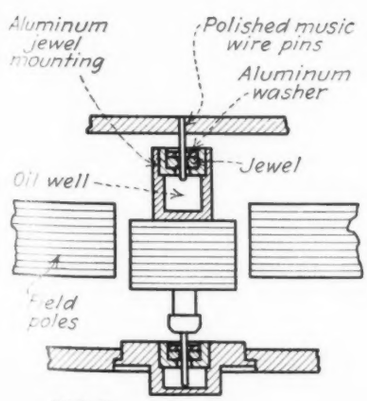


FIG. 5

Fig. 5—To retain the lubricant an oil well is provided below for each of the bearings of the rotor. Jewels are mounted in identical aluminum cups and pressed into the rotor and lower bearing cap

factory material for small bearings. For olive jewels and end-stones, sapphire is used to resist wear under conditions of high unit pressures. These bearings in smaller sizes can be supplied in quantities for about 35 cents or less. Under extremely severe service conditions, the additional expense for diamond jewels may be necessary, but diamond is more brittle than sapphire and may shatter under impact loads. Genuine rubies make good bearings but at present are rarely used because of scarcity and high price.

In shaping the rough stone into a finished jewel the manufacturing operations are somewhat similar for all jewel materials. Because of the extreme hardness—which is the reason for their use for bearings—cutting and shaping operations are relatively slow. Thus, the jewel material is expensive not only because of its scarcity but also because the manufacturing process is slow and costly. However, jewel bearing manufacturers have been successful in adapting their processes to quantity production methods, thereby producing small bearings at a relatively low cost.

Manufacturing processes used in making sapphire bearings depend upon the form in which the raw material is obtained. Natural sapphires are received from the mine in the form of rough pebbles. Each pebble is cemented to a block and ground flat on two sides parallel to each other, using a diamond-charged disk. After the stone is ground to the thickness dimension of the jewel bearing, it is turned to the required diameter, using a lathe and a diamond cutter. The hole is bored with a diamond drill, and a reamer charged with diamond dust is used to bring the diameter almost to the required dimension. Another reamer charged with a finer grade of diamond powder is used to bring the hole diameter to size, at the same time giving the surface a high polish.

The manufacture of synthetic sapphire starts with a pure aluminum oxide in the form of a fine white powder, which is fed periodically in small quantities into the tube of an inverted oxy-hydrogen blowpipe. The powder is fused by the flame and falls to a clay rod placed in a small furnace heated by the blowpipe. By regulating the temperature and the quantity of powder supplied, the fused particles build up into a "boule."

Synthetic sapphires, because of the larger size of the stone, are formed into jewels by a somewhat different process than used for natural stones. The "boules" are split lengthwise and cut into plates of the required thickness, as shown in Fig. 4, using diamond charged copper disks rotated at high speed. Cylindrical disks are then cut from the sapphire plates by drilling with diamond dust using hollow copper drills. Subsequent manufacturing operations for forming the hole are the same as used with natural stones.

In regard to lubrication, many jewel bearings carrying light loads give satisfactory service without oiling, and tests reported by jewel bearing designers indicate that lubrication does not appreciably reduce friction. But, where unit pressures are high, engineers both here and abroad strongly recommend lubrication to decrease wear, particularly in the journal. A series of tests recently conducted by Verney Stott at the National Physical Laboratory in England demonstrates that where wear is a factor lubrication multiplies the useful life of a jewel bearing by several times. As explaied by Mr. Stott, lubrication not only reduces the amount of debris formed at the point of contact, but any debris formed is distributed throughout the oil instead of accumulating at the point of contact. Thus, oil tends to reduce the damage to the polished surfaces of the jewel as well as decreasing the wear in the softer journal, so that bearings having high unit pressures and small contact area are given greatly increased bearing life.

It is difficult to select an oil that will not corrode, break down, gum or creep over long periods of time. Although often used in watches and clocks, fish oils or vegetable base oils tend to oxidize, and the oxidation products corrode the shaft. A suitable lubricant in general use for jewel bearings is prepared from a mineral oil. However, some of these oils tend to creep with the result that in time all the oil is drawn out of the bearing. This creep on metal parts can be prevented by dipping the parts individually or assembled in a one per cent stearic acid solution, using equal parts of pure carbon tetrachloride and toluene for the solvent and merely drying the parts before oiling. In some light-duty designs where servicing is difficult, it may be advisible to design the bearings to operate dry, selecting a bearing shape giving a low unit bearing pressure.

At the elevated temperatures found in some electrical devices, the oil thins and tends to flow out of the bearing. In the small timing motor shown in Fig. 1, for example, lubrication is necessary because of the appreciable radial loads on the jewel bearings. Both upper and lower bearings are designed so that their oil supply will be sufficient for two years' continuous operation. To retain the oil in the top bearing of the vertical rotor

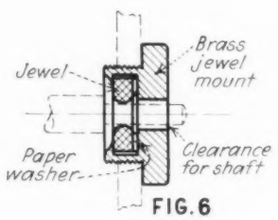


FIG. 6

Fig. 6—Paper or leather washers are used to prevent the jewel from cracking when it is spun into the brass jewel mount in this radial bearing

shaft, the bearing is inverted, the jewel being inserted in the rotor and the bearing pin in the motor frame, as shown in the diagram, Fig. 5. It will be noted that even though a relatively heavy rotor is used, no thrust bearing is needed for this vertical shaft since the field poles are positioned so that the magnetic field lifts the rotor when the motor is running.

Because the jewel material is easily fractured, provisions must be made in mounting the jewel bearing to distribute the clamping load uniformly. For this reason jewels are mounted in a separate brass or aluminum bushing which is usually screwed in place, the bushing then taking the clamping loads. The jewel is held in a counterbore in the bushing by spinning a lip over the edge of the jewel. Paper or leather washers, the same diameter as the jewel, are placed behind the bearing to equalize the pressure around the edge during the spinning operation. For a hole jewel such as shown in Fig. 6, the bushing is drilled for a generous clearance over the shaft and is counterbored for the outside diameter of the jewel. Since the proportions as well as the tolerances in the outside dimensions of the jewel vary somewhat with different manufacturing processes the dimensions of the counterbore are usually supplied by the jewel bearing manufacturer.

Gear Trains for Changeable Speed Ratios—II

Formulas and method of procedure for determining the numbers of teeth in the gears of a train and demonstrating how the maximum economy can be achieved. The first installment of this article appeared in the February issue

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USING three shafts and ten gears arranged as shown in Fig. 4, a series of eight speed changes in geometrical progression will be obtainable. The variable-speed shaft may be connected with the intermediate shaft by any one of four pairs of gears giving four speeds, say, N, kN, k^2N and k^3N. The intermediate shaft must be connected with the constant-speed shaft 3 by two pairs of gears, giving the former two possible speeds, one k^4 times the other. This results in having the entire eight speeds in geometric progression.

The gear train shown in Fig. 4, consisting of three shafts and ten gears and making available eight speed changes, will be used to illustrate the derivation of a series of equations by which one can arrive at the required numbers of teeth in the various gears. If A and F are the smallest gears and B and E the largest on their respective shafts, the following two equations must be satisfied:

$$\frac{B}{F} \times \frac{E}{A} = k^3 = a \tag{1}$$

$$\frac{E}{I} \times \frac{J}{F} = k^4 = b \tag{2}$$

The capital letters represent the numbers of teeth in the respective gears, and a and b are given as the values of the ratios to make the equations general. If the sums of the numbers of teeth in the gears connecting adjacent shafts are alike the differences between the largest and the smallest gear on each shaft must also be alike. Taking this difference as M, the following three equations can be written:

$$B - A = M \tag{3}$$

$$E - F = M \tag{4}$$

$$J - I = M \tag{5}$$

At the fourth speed from the bottom of the series, I will drive A through E as an idler, and this gives the equation:

$$\frac{A}{I} = r \tag{6}$$

where r is the ratio of the constant-speed shaft velocity to the corresponding speed of the upper shaft, when I and A are both in mesh with the intermediate idler E.

If a, b and r are determined by the conditions of the drive, the above six equations can be satisfied by choosing appropriate values for the seven remaining unknown quantities. Two limitations in the solution are that M should not be too large and that the smallest gear in the set must not have fewer teeth than is permitted by good design nor so many teeth that the gear case becomes too bulky. To meet these limitations the six equations might well be reduced to one with two unknown quantities, M and the number of teeth I in the smallest gear. By a process of elimination, the following equation is secured:

$$I = M \frac{r - c}{r(c - 1)} \tag{7}$$

$$c = b/a$$

In this example c equals k. If the four speed changes had been placed between the lower and intermediate shaft and only two in the upper set, the ratio would have been reversed and c would equal $1/k$.

One point immediately apparent from the equation is that if c is greater than unity, r must be less than c. If c is greater than unity, the constant-speed shaft must run faster than the variable speed by a ratio greater than k when both I and A are in action. On the other hand, if c is less than unity, the driving shaft must run materially slower than the corresponding speed of the upper shaft.

The 16-speed, 20 to 500 r.p.m. shaft used in earlier examples is chosen to illustrate the use of these equations. It is assumed that a back gear train having a ratio of k^8 or 5.57 is used to give the lower half of the speeds, so the immediate problem is to determine the ten gears which will give the upper eight speeds of this series. The constant-speed shaft is to run at 450 r.p.m. and the upper shaft should go at 212 r.p.m. when both I and A are in action. The

value of r is then 2.13 and c equals k or 1.24. Equation (7) then becomes:

$$I = 1.74\,M$$

Taking M as 12, I will be 21, which is a trial solution that gives a reasonable value for the pinion I. Substituting back into the equations, we get $A = 45$, $J = 33$, $B = 57$, $F = 24$ and $E = 36$. One possibility of trouble, having F come out too small, is fortunately avoided in the above solution. The remaining four gears are determined by using the equations:

$$\frac{B}{F} \times \frac{G}{C} = k$$

$$\frac{B}{F} \times \frac{H}{D} = k^2$$

Remembering that the sums of the numbers of teeth on mating gears must be constant, the closest solutions in this example are $C = 53$, $D = 49$, $G = 28$ and $H = 32$. The speeds given by this gear combination compared with the ideal are given in Table IV. It is seen that a close approximation to the desired values is secured in this train, using ten gears of reasonable size to secure eight changes in speed.

The maximum economy in a sliding-gear transmission comes when nine gears mounted on three shafts, as shown in Fig. 5, are used to give nine changes in speed. While a geometric progression is impossible with this arrangement, a series of speeds may be worked out which is satisfactory for some machines. An analysis developed by the writer is given in the following paragraphs:

The lowest speed N of the variable-velocity shaft comes when gears A and E are in mesh with D and H respectively. If the contact between the constant-velocity and intermediate shafts is changed so that C drives F, the speed N is multiplied by the factor k_1, where:

$$k_1 = \frac{D}{A} \times \frac{C}{F}$$

By the same process of reasoning it is seen that there are three other multipliers, as follows:

$$k_2 = \frac{D}{A} \times \frac{B}{E} \qquad k_3 = \frac{H}{E} \times \frac{F}{I} \qquad k_4 = \frac{H}{E} \times \frac{D}{G}$$

The various combinations of these factors, as shown in the third column of Table V, can be used to give nine speeds to the variable-velocity shaft. The problem then resolves itself into the selection of the four factors so that their various combinations will give the closest approximation possible to a geometric progression. It is complicated by the fact that the choice of three of them practically determines the value of the fourth.

As a first step k_1, k_2, k_3 and k_4 can be taken as powers of some constant d, and the total amount by which to multiply N for each speed can be determined in terms of d to various powers. Out of a number of combinations the writer has chosen $k_1 = d^{1.375}$, $k_2 = d^{3.75}$ and $k_4 = d^3$. By the following reasoning k_3 was then taken as $d^{1.9}$. Thus, k_2 can be split into two ratios, $k_1 = d^{1.375}$, and a second value $d^{2.375}$. The four gears giving this second ratio include the same units on the intermediate shaft as the four gears giving the ratio k_3. The overall ratios between the intermediate shaft and the two outside shafts are $d^{3.75}$ and d^3 respectively. The selection of 1.9 for the power of d in the third ratio k_3 is obtained from the following proportion:

$$3.75 : 3 = 2.375 : 1.9$$

The successive speeds of the variable velocity shaft in terms of N and powers of d are given in the fourth column of Table V for the proposed series and the values for a geometric progression in the same units are given in the next column for comparison. A good problem for one interested in puzzles would be to work out a combination which will more closely approximate a geometric progression.

As an illustration, these methods are applied to the problem of Table IV, only adding one more speed at the upper end of the series. The r.p.m. of the constant-speed shaft is 450 and the variable-velocity shaft has nine steps from 111 to 620 r.p.m. The value of d is found by the equation:

$$d = \sqrt[6.75]{\frac{620}{111}} = 1.29$$

This gives the following ratios:

$k_1 = 1.42$ $\quad k_2 = 2.60$ $\quad k_3 = 1.62$ $\quad k_4 = 2.15$

The gears involved in k_2 and k_4 may be determined by use of Equations (1) to (7) with due regard to changes in letters. For instance, gear A in Fig. 4 occupies the position of I in Fig. 2 (February *P.E.*, p. 50). Using Equation (7):

$$r = \frac{k_4 N}{450} = 1.882 \qquad c = \frac{b}{a} = \frac{k_2}{k_4} = 1.21$$

$$A = M\frac{1.882 - 1.21}{1.882(1.21 - 1)} = 1.7M$$

Taking M as 13, A equals 22, $B = 35$, $G = 41$ and $H = 54$. Substituting these values in (1) and

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As a follow-up of A. L. DeLeeuw's article on hydraulic versus mechanical feeds and this one on change gears, we will present several comprehensive articles on hydraulic operation and control of machines. The first of these, by Hans Ernst of the Cincinnati Milling Machine Company, will appear in an early number

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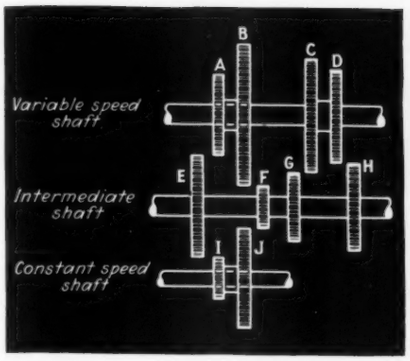
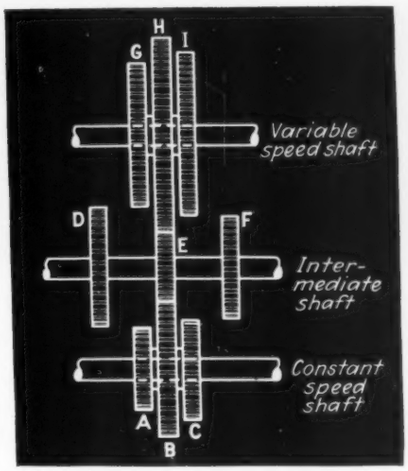


Fig. 4—With this arrangement, using only three shafts and ten gears, eight-speed ratios are obtained

Fig. 5—Maximum economy for nine-speed ratios is attained when nine gears are mounted on three shafts



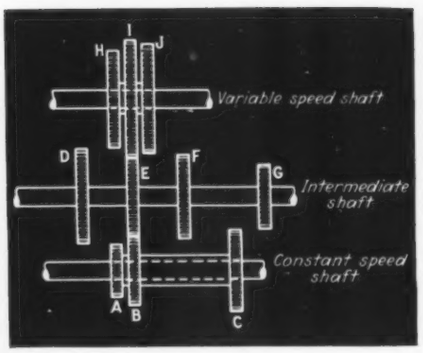


Fig. 6—Irregularity in the progression of the speed ratios obtained in the arrangement shown in Fig. 5, can be corrected by adding another gear

TABLE IV

Speeds in 8-speed 10-gear transmission shown in Fig. 4

Speed No.	R.P.M.	
	Geom. Prog.	Actual
1	111	110
2	138	139
3	171	171
4	212	210
5	262	260
6	325	327
7	404	405
8	500	495

TABLE V

Speeds in 9-speed 9-gear transmission shown in Fig. 5 as calculated by two methods

Speed No.	Gears In Contact	R.P.M.			Calculated r.p.m.		
		Using Multiplier k	Using Multiplier d	Geom. Prog.	By Geom. Prog.	By Proposed Ratios	By Gears Chosen
1	AD, EH	N	$\cdot$ N	$\cdot$ N	111	111	113
2	CF, EH	k_1N	$d^{1.38}N$	$d^{0.84}N$	138	158	163
3	AD, FI	k_3N	$d^{1.9}N$	$d^{1.69}N$	171	180	183
4	ADG	k_4N	d^3N	$d^{2.53}N$	212	239	242
5	CFI	k_1k_3N	$d^{3.28}N$	$d^{3.38}N$	262	256	264
6	BEH	k_2N	$d^{3.75}N$	$d^{4.22}N$	325	289	292
7	CF, DG	k_1k_4N	$d^{4.38}N$	$d^{5.06}N$	404	339	348
8	BE, FI	k_2k_3N	$d^{5.65}N$	$d^{5.90}N$	500	468	473
9	BE, DG	k_2k_4N	$d^{6.75}N$	$d^{6.75}N$	620	621	622

TABLE VI

Speeds in 9-speed 10-gear transmission shown in Fig. 6

Speed No.	R.P.M.	
	Geom. Prog.	Actual
1	111	110
2	138	137
3	171	170
4	212	210
5	262	262
6	325	324
7	404	400
8	500	497
9	620	616

(2) gives $D = 34$ and $E = 21$. The three remaining gears are readily determined, using the factors k_1 and k_3, and are found to be $C = 27$, $F = 29$ and $I = 46$. The last three columns of Table V shows the speeds which these gears would produce in comparison with the proposed values in terms of d and also with a geometric progression.

While this gives a series of nine speeds between definite limits, it may not be satisfactory because of the irregular progression. It is possible to correct this defect by increasing the number of gears to ten as shown in Fig. 6. Here gears A, B and C are on one sleeve and mesh with D, E and G respectively, while H, I and J mesh with D, E and F. In the solution the following expressions are used in combination with Equation (7):

$$a = \frac{D}{H} \times \frac{I}{E} = k^3 \qquad \frac{D}{H} \times \frac{J}{F} = k$$

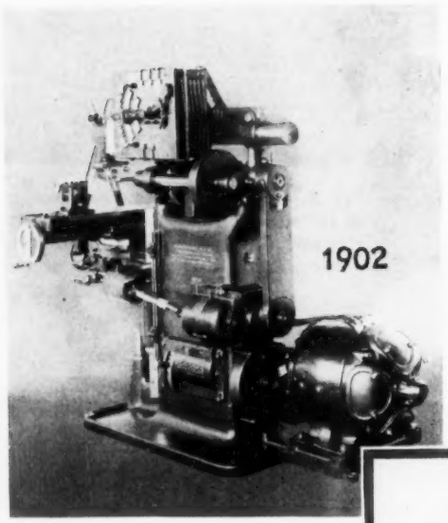
$$b = \frac{D}{A} \times \frac{B}{E} = k^3 \qquad \frac{E}{B} \times \frac{C}{G} = k^3$$

Where k is the multiplier of the geometric progression.

For a constant speed shaft running at 450 r.p.m. a speed range of 111 to 620 r.p.m., making $k = 1.24$, and a minimum pinion size of 20 teeth, this gave gears as follows: $A = 22$, $B = 32$, $C = 42$, $D = 42$, $E = 32$, $F = 37$, $G = 22$, $H = 58$, $I = 68$ and $J = 63$. The result was not entirely satisfactory because the intermediate shaft had a maximum speed of 860 r.p.m. Therefore a second series was figured with the constant velocity shaft running at 400 r.p.m. This gave gears as follows: $A = 20$, $B = 30$, $C = 41$, $D = 47$, $E = 37$, $F = 42$, $G = 26$, $H = 47$, $I = 57$ and $J = 52$. The resulting speeds closely approximate a geometric progression, the only lapse being that the three top figures are about 2 per cent high. Even this variation can smoothed out if we take the blank for the 41-tooth gear C and cut 40 teeth on it, using a hob or shaping cutter to generate the teeth. It will then run satisfactorily with the 26-tooth pinion on the original center distance. In Table VI are given the resulting speeds.

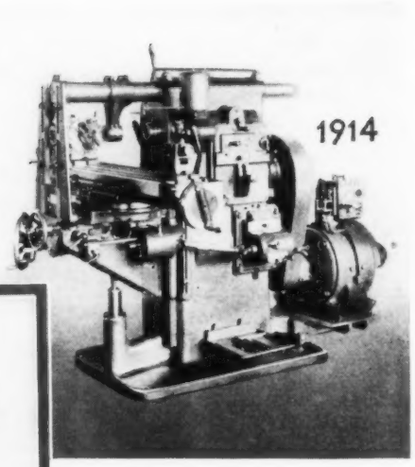
With the procedure set forth here, one can determine the numbers of teeth for the change gears to give any desired number of speed ratios substantially in geometrical progression within any specified speed range. As shown by the accompanying tables the actual speeds obtained by this method deviate only slightly from the exact geometrical progression. For all practical purposes, these small differences can be ignored as they would not be noticeable.

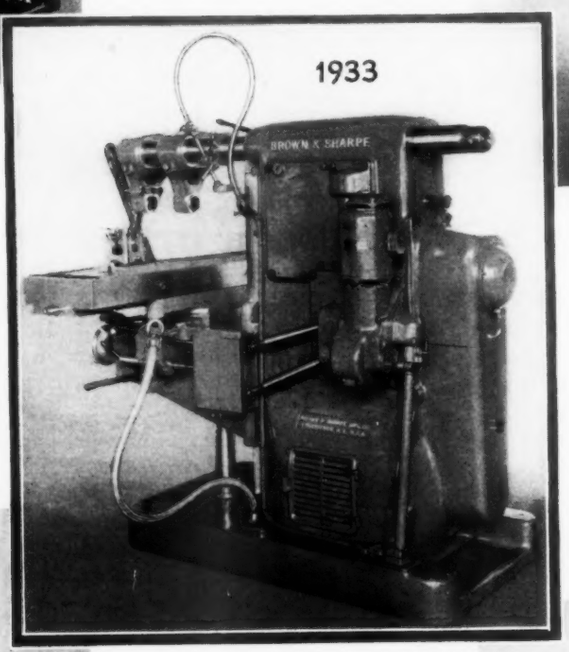
New Developments in Motor Drives



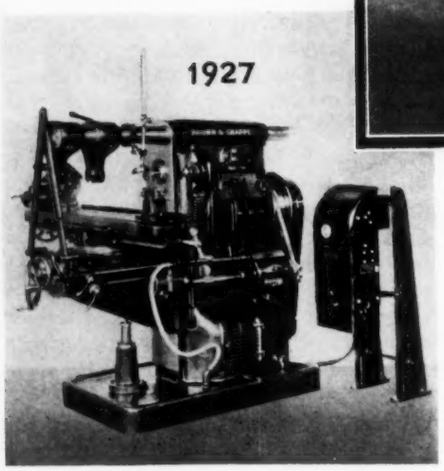
The first direct motor-driven machines were an aggregation of a modified belt-driven machine and stock electrical units whose bulkiness made impossible a compact design

During the next twelve years there was relatively little progress toward smaller electrical units. Here we see the old hand-starter placed on top of the motor which is mounted on a pivoted base



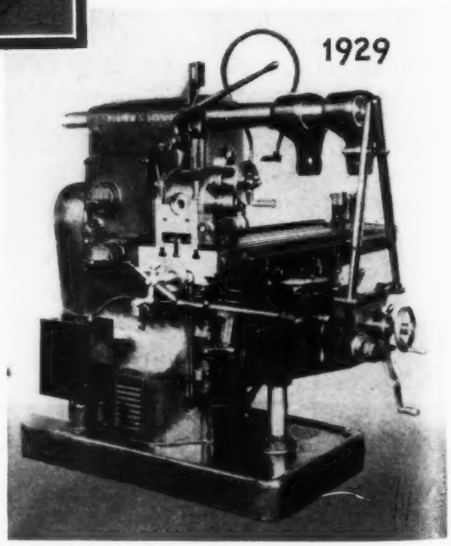


Here we see the control box greatly reduced in size and mounted close to the motor to minimize the amount of high-voltage wiring. Note the push-button station at the top of the machine

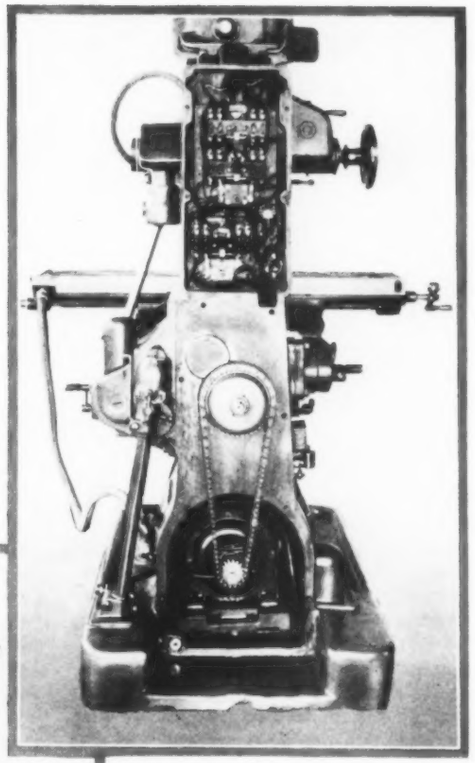


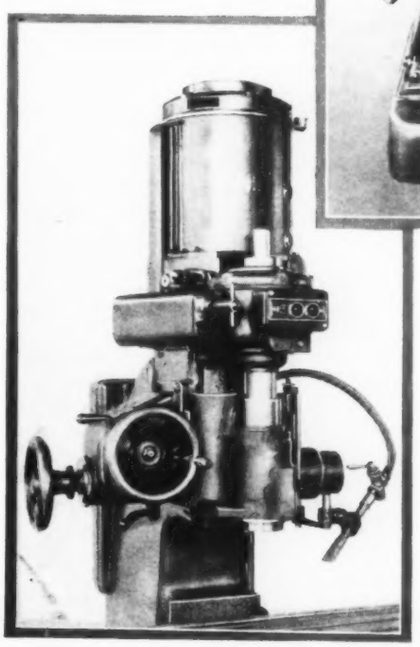
One of the early applications of automatic controls. The panel box is so large that it had to be mounted separately. But the motor has been designed small enough to be housed in the machine

One of the latest models of motor-driven milling machines with main motor and control panel housed in the machine. The vertical motor on the side of the machine drives the table power fast travel mechanism and the coolant pump. A detailed description of the motors and controls on this machine is given on the opposite page



and Controls for Machine Tools





Feed motor and control panel for the vertical spindle milling machine. Separate covers are provided for the electrical control panel and the motor compartment including the chain guard

To the left of the "forward-reverse-stop" pushbutton station is the drum type control for the four-speed motor that drives the vertical spindle

NUMEROUS improvements in the compactness, reliability and mechanical construction of electric motors and controls have opened wonderful opportunities in the design of power-driven machines. A glance at the photographs of the 1929 and 1933 models of milling machines shown on the opposite page gives only a hint of what can be done.

In the Brown & Sharpe 1933 universal milling machine shown on the opposite page, the driving motor is mounted in a compartment in the lower part of the column. An oil-tight roof over the motor affords complete protection from oil, chips and dirt. Louvers on the side give ample ventilation. The same design of motor mounting is used for the feed motor of the B & S vertical spindle milling machine, a rear-end view of which, with covers removed, is shown on this page. On the right side of the column at the base can be seen the removable cover that protects the swing-bolt adjustment for the pivoted bracket.

In the latest designs of both the universal and the vertical spindle milling machines illustrated here the electrical controls are mounted on the rear face of the column, directly above the motor, thereby requiring only a minimum amount of wiring. One feature of the universal machine is that the machine starting switch is located on the rear face of the column and is operated through a mechanical linkage by a lever conveniently located near the front of the machine.

In the vertical spindle milling machine a four-speed induction motor drives the spindle, this motor being designed as an integral part of the spindle head assembly, and its rotor shaft is mounted on anti-friction bearings. To the left of the push-button station shown in the above photograph can be seen the handle of the drum-type control for selecting the motor speed. The drive from the rotor to the spindle is either direct or through back gears, giving eight spindle speeds.

Both the spindle motor and the constant speed feed motor are started and stopped by the push-button control station at the spindle. Reverse button, however, reverses only the spindle motor. An unusual feature is the electrical interlock between the spindle motor and the feed motor. If for any reason the spindle motor fails or the feed crowds the cutter, thereby overloading the spindle motor, the feed motor is automatically stopped. This is done through a relay in the control.

It will be noticed that no external wiring is visible. All the wiring runs through ducts cored in the machine. For convenience and economy wiring harnesses are used. A detailed wiring diagram giving the length of each wire is made, from which the various wires are cut to length and connected as may be required. All the wire ends are labeled with a metal tag which indicates the terminal to which that wire end is to be fastened. If only a few wires are used, identification is by means of different colored insulation on the wire.

COMMUNICATION and COMMENT

Mating Gears Rotating in the Same Direction

W. A. TUPLIN
Huddersfield, England

Where it is necessary to have two parallel shafts at small center distances rotating in the same direction, a special type of involute gear can be used. In demonstrating the generation of the involute gear tooth form a cord is passed transversely between two drums, a point on the cord describing an involute arc in relation to either of the drums as they revolve in opposite directions. If the cord is arranged to form a direct tangent, a point on the cord still describes an involute with respect to the drums, but the two drums revolve in the same direction. This principle was used to develop a special type of gearing in which meshing gears rotate in the same direction.

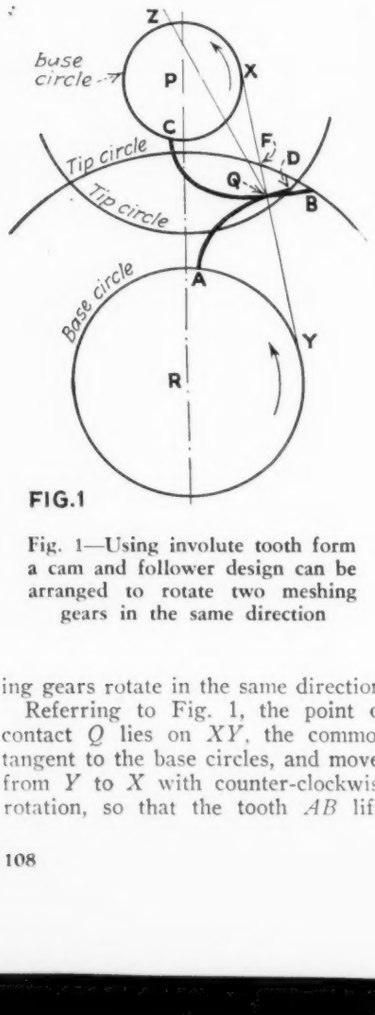


FIG.1

Fig. 1—Using involute tooth form a cam and follower design can be arranged to rotate two meshing gears in the same direction

Referring to Fig. 1, the point of contact Q lies on XY, the common tangent to the base circles, and moves from Y to X with counter-clockwise rotation, so that the tooth AB lifts the tooth CD similar to the action of a cam and follower. Friction at the point of contact directs the contact force along the line QZ, causing rotation of the upper gear if QZ passes to the right of P. Assuming that rotation occurs, Q advances to F, the intersection of the tangent line and the tip circle of the gear R, the tooth contact stopping at this point. To continue rotation of gear P, another pair of contacting teeth must be provided in a parallel plane. By adding a sufficient number of pairs of teeth, a continuous drive can be obtained as shown in Fig. 2. With an infinite number of teeth the drive consists of two single-tooth helical gears.

In the case of equal 2-tooth gears, if the width of the tooth is too great, the tooth of one gear, in moving across the line of centers, may foul the second tooth. On the other hand, there will be excessive backlash if the width of the tooth is too small. When each gear makes contact with the other at two points, one on the leading profile and one on the trailing profile, there is no backlash. Using the geometry of the involute, the dimensions of the teeth can be determined when center distance and base circle dimensions are known for any given application. With some combinations of tip circle and base circle diameters, it may be impossible to arrange two teeth on each gear.

Because of the relatively large amount of friction that takes place between the contacting teeth, the practical application of gears of this type is limited. Although the loss of power would be greater than with normal spur gears of the same dimensions, this might not be serious in some cases as the loss by tooth friction in accurately made gears of the ordinary type is less than one per cent. In actual application the teeth would be made of helical form, and it would be desirable to keep the spiral angle small to reduce transmission losses.

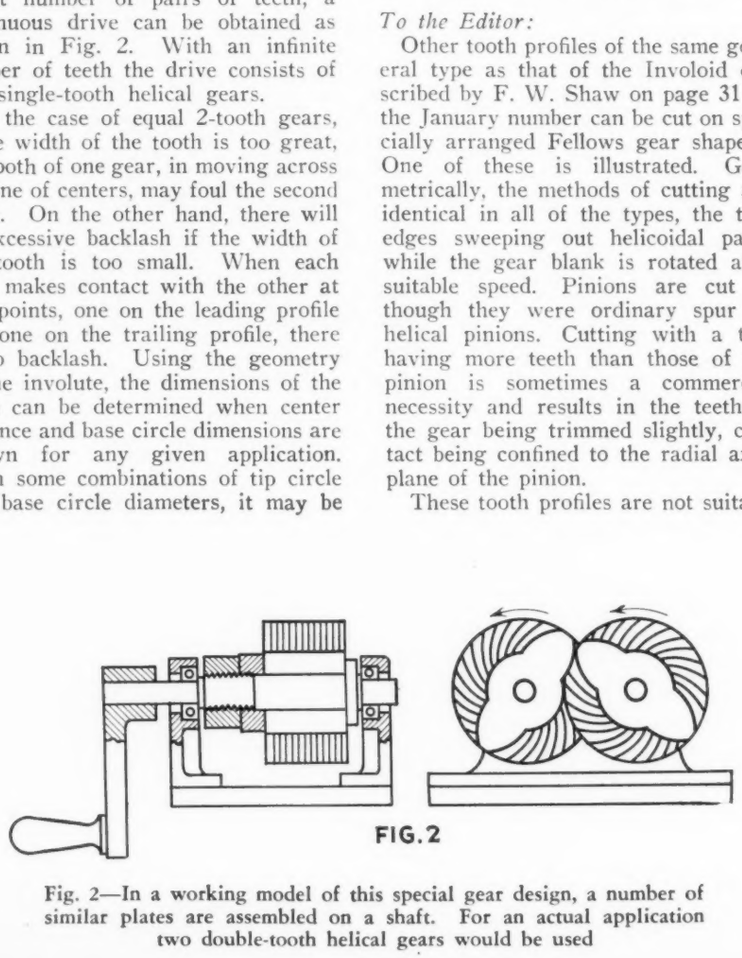


FIG.2

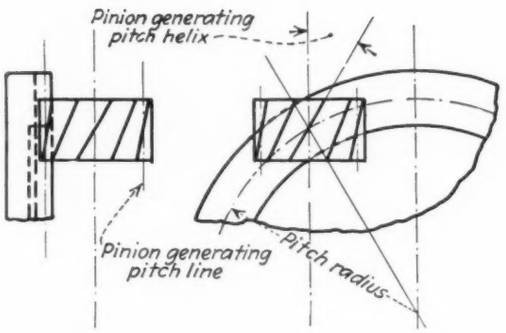
Fig. 2—In a working model of this special gear design, a number of similar plates are assembled on a shaft. For an actual application two double-tooth helical gears would be used

Other Involoid Gears

To the Editor:

Other tooth profiles of the same general type as that of the Involoid described by F. W. Shaw on page 31 of the January number can be cut on specially arranged Fellows gear shapers. One of these is illustrated. Geometrically, the methods of cutting are identical in all of the types, the tool edges sweeping out helicoidal paths while the gear blank is rotated at a suitable speed. Pinions are cut as though they were ordinary spur or helical pinions. Cutting with a tool having more teeth than those of the pinion is sometimes a commercial necessity and results in the teeth of the gear being trimmed slightly, contact being confined to the radial axial plane of the pinion.

These tooth profiles are not suitable



One of the crown-type worm gear tooth profiles similar to the Involoid, that can be generated on a Fellows gear shaper

for transmission of high loads at high speeds, nor are they relatively silent in operation in all reduction ratios. For moderate speed and load conditions, they do have possible applications since they can be easily mounted and can be shaped from cast blanks with little finish allowance.

Cast-iron gears, with a hardness of 165 Brinell, 103 teeth, 8 pitch, $\frac{3}{4}$-in. face have been cut from solid blanks in less than four minutes cutting time. The relative straightness of this tooth profile permitted the use of heavy feeds without loss of shape by excessive flatting. —ROLAND V. HUTCHINSON
Lansing, Mich.

Unfair to the Belt Drive

J. R. HOPKINS
Chicago Belting Company

Machine designers should recognize that no machine is correctly designed until it is hooked up and running, and that the machine must be designed for economy and good engineering in the drive and motor, as well as in the machine itself. The trouble is that machine designers seldom select a large enough driven pulley so that flat belts or V-belts run at their best operating speeds. For example, in a slide press which is now being sold for individual drive, a V-belt driving a 32-in. flywheel runs at a speed of only 365 ft. per min. As shown in the accompanying table, V-belts should be used at a speed of 2,000 and 3,000 ft. per min.

Type of Drive	Linear Speed ft. per min.
Chain	1,000-1,500
V-Belt	2,000-3,000
Flat Belt	3,000-4,000

In addition, many machine tools are designed for too wide a range of loads, with the motors and belts specified for the maximum load. Many machine tool builders do not even know what loads their own machines will require in customers' plants. There must be a tremendous waste in designing machines to such wide limits.

Error in Worm Gear Formula

To the Editor:

In the February number there is a very valuable article on "Practical Data and Formulas for the Design of Worm Gears." I believe, however, that there is an error in Formula (3) on page 64. It does not seem correct to have the Barth factor added to the expression for the material and service factor, $\frac{MF}{SF}$ Usually in formulas of this kind these two factors are products, being multiplied together instead of being added.

I also wish you would confirm the statement in the text that, ". . . the design procedure given here has formed the basis for a great number and variety of designs that have given satisfaction in many fields of service." —C. U. NORTH
Bay City, Mich.

Editor's Note:

Mr. North is correct, the formula was printed:

$$La = TLs\left(\frac{600}{600 + Vw} + \frac{MF}{SF}\right)$$

It should read:

$$La = TLs\left(\frac{600}{600 + Vw} \times \frac{MF}{SF}\right)$$

As to confirming the statement, "the design procedure given here has formed the basis for a great number and variety of designs that have given satisfactory service in many fields," the author of the article, C. H. Grill, was formerly chief engineer of the Philadelphia Gear Works.

A Warning and An Explanation

To the Editor:

The October 1933 issue of your publication has just come to my attention, and I notice on page 370 there is given a tabulation of some "Properties of Corrosion-Resisting Alloys," which does not appear to be part of any particular article. Inspection of this table shows that it is full of errors, and may possibly be dangerously misleading to such of your readers as may choose to use it as a guide in their selection of materials for specific purposes.

For example, I notice that Monel metal is said to be not resistant to dilute sulphuric acid at 68 deg. F. As you probably know, Monel metal is considered a standard material for use in connection with dilute sulphuric acid even at much higher temperatures than 68 deg. F., as in the construction of equipment used in the pickling of steel with hot, dilute sulphuric acid. Similar comments apply to dilute hydrochloric acid at 68 deg. F. which Monel metal resists very well, although the tabulation says that it does not. On the other hand, the table indicates that Monel possesses good resistance to aqua ammonia, both dilute and concentrated, whereas the fact is that the resistance of Monel metal to ammonia corrosion is considerably inferior to its resistance to sulphuric acid corrosion.

I might go on and cite other incorrect statements in the table which in general is so misleading that I believe it would be wise for you to warn readers against its general use as a guide in some early issue of your publication. —F. L. LAQUE
Development and Research Department International Nickel Company, Inc.

To the Editor:

We are indeed sorry to learn that you have suffered adverse criticism through your publication of the table in question in the October issue of *Product Engineering*. We shall make a few comments as a possible explanation for misunderstandings on the part of readers and also in justification of the table.

It is somewhat unfortunate that the tabulation was entitled "Properties of Corrosion-Resistant Alloys." It is this laboratory's view that "Properties of Typical Laminating (or Laminated) Metals" would have been more appropriate. Nor did a caption denote the true purpose of the table, which was meant merely as a general guide supplementing the article on laminated metal. It was not meant as a critical and comprehensive table on corrosion-resistant materials, as implied by the title of the table.

Mr. LaQue of the International Nickel Company no doubt perused the table in a critical frame of mind and when he noticed the "many grave errors," especially as regarding the resistance to corrosion of his company's products, he was naturally disturbed. Evidently, he did not read the article on "Laminated Metals" or

he would have seen the connection of the table. He could not have known its purpose or connection from the title of the table.

In justification of the data as presented in the tabulation, we wish to state that the information had been gathered together for our own use from many sources which we considered reliable. The particular data on Monel metal which has been so severely criticized was taken from tables published by the American Society for Testing Materials. This set of tables was part of the society's *Proceedings*, Vol. 30, Part 1, 1930. Quoting their table we find for the corrosion resistance of Monel in sulphuric acid (all concentrations) and hydrochloric acid (all concentrations), "Varies with individual conditions—consult manufacturer." This statement to us had the meaning of not being generally resistant. For ammonium hydroxide under all concentrations we find "recommended."

Since the data presented in these A.S.T.M. tables had been supplied by manufacturers themselves, we think they are as reliable as any table can be. Perhaps our interpretation of the resistance of Monel metal to the acids in question is not fair to Monel metal, but that is the way we saw it. Upon perusal of a late bulletin by the International Nickel Company, we find that the data conflict to a certain extent but not too severely. We agree that a question mark in the column would have been more diplomatic than a direct "no."

Of the remaining data, some of it has been taken from our own laboratory records; the remainder has been gathered together from the A.S.T.M. tables; charts published by *Chemical & Metallurgical Engineering;* and from the bulletins of various manufacturers.

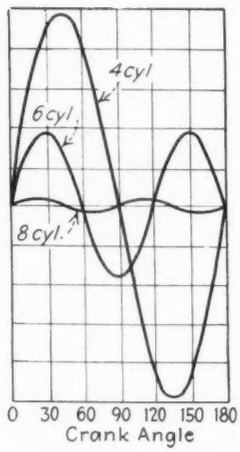
We trust that these comments will serve to explain any misinterpretations and help to maintain cordial relations between all parties concerned.

—A. W. PETERSON,
Metallurgist, General Plate Company

Engine Vibration

L. D. HAGENBOOK
Designing Engineer
Northwest Engineering Company

In gasoline engines the only unbalancing forces generally considered are those of the inertia of the reciprocating masses in the various planes perpendicular to the axis of the crankshaft. This procedure takes no account of the mechanical unbalance that produces a rocking couple tending to vibrate the engine about an axis parallel with the crankshaft. The position of this vibrational axis depends on the distribution of the masses and the nature of the restraint offered by the mountings. Because of the concentrated mass of the flywheel this axis inclines downward to a point near the universal coupling, giving but little displacement at this point.



$$F = 0.0000142\,WSN^2\left(\cos A + \frac{1}{2n}\cos 2A\right) \quad (1)$$

$$L = \frac{S}{2}\left(\sin A + \frac{\cos A \sin A}{\sqrt{4n^2 - \sin^2 A}}\right) \quad (2)$$

$$T = 0.00000355\,WN^2S^2\left[\sin 2A + \frac{\sin 2A \cos A}{\sqrt{4n^2 - \sin^2 A}} + \frac{1}{n}\cos 2A \sin A + \frac{1}{2n}\left(\cos 2A \frac{\sin 2A}{\sqrt{4n^2 - \sin^2 A}}\right)\right] \quad (3)$$

$$T_4 = 4K\left(\sin 2A + \frac{1}{2n}\frac{\cos 2A \sin 2A}{\sqrt{4n^2 - \sin^2 A}}\right) \quad (4)$$

F = Force in lb.
N = R.p.m.
A = Angle of crank from top dead-center
W = Weight of mass in lb.
S = Stroke in in.
n = Ratio of connecting rod length to stroke

In gasoline engines of equal displacement, both the relative magnitude and frequency of the vibrating forces vary with the number of cylinders

Inertia forces F acting on the piston, as calculated by Equation (1), exert a torque on the crankshaft and flywheel, producing an equal and opposite reaction on the engine block. The inertia torque acting through the lever arm L, Equation (2), causes a vibration torque T, the product of F and L, as shown in Equation (3).

Of the four terms in Equation (3), the first is a second harmonic, the second and third are third harmonics and the last one is a fourth harmonic. In a four-cylinder engine the total vibrational effort is given by Equation (4), showing that only the second and fourth harmonics are present. In a six-cylinder engine the second harmonic drops out and also most of the fourth harmonic, leaving the third harmonic dominant. As shown in the accompanying curve, the total vibrational torque for the six-cylinder engine is much less than for a four. In a straight-eight engine, the first, second and third terms drop out leaving only a fourth harmonic.

When the linear inertia forces of the pistons are considered, there is no unbalanced primary couple in 4-cycle engines having two, four, six and eight cylinders in line. But in the two and four-cylinder engine the secondaries of linear acceleration of the pistons are additive while in the six and eight they are subtractive and cancel out altogether. It is usual to assume that a six and eight-cylinder engine are in perfect balance, but there is a vibrating couple in both acting on an axis parallel with the crankshaft, the six-cylinder engine having more vibration.

In engines of four, six and eight cylinders the frequency of torque impulses is of the same order of harmonic as the vibrating forces, but they are opposed in phase. Thus, at low speed and high torque the explosion impulses predominate, causing the engine to vibrate. At a higher speed the inertia forces increase and at some point almost completely balance the explosion reactions, eliminating the vibration at this speed. At still higher speeds the inertia forces predominate and the engine again vibrates. This effect is noticeable on certain engines, and is much worse when the engine is idling at full speed than when it is under load at the same speed.

Does Bigger Mean Better?

To the Editor:

We have come to look upon the automobile as representing our most progressive industry. How far is this appraisal justified, or have we engineers allowed ourselves to be carried away with advertising phrases primarily intended for the general public? Is it not a good time for the industry to look at the situation calmly and take account of stock?

Ever since the days of big production we find a surprisingly uniform policy of so-called progress in every line of cars. We start with a small car as the price leader and tell the buyers-to-be of its advantages because of convenient size, light weight, economy and all the rest. But in spite of its being almost perfection we add a few inches of wheelbase, make it heavier and of course put in a bigger motor from year to year. Very soon the advertised virtues of the small car disappear and in its place we have a car of from 119 to

125-in. wheelbase and weighing well over 4,000 pounds.

Then we bring out another small car in the line and go through the same alleged progressive evolution. The only real changes are in making it bigger, heavier and less economical, which is at least a doubtful kind of progress. The automotive industry developed the light, strong alloys of steel and of nonferrous metals, but uses them all too sparingly. We blame the railroad engineers for constant increase in the weight of the equipment, and then follow suit with ever heavier automobiles.

One alibi is that weight makes for easy riding, yet we know of 6,000 lb. cars which ride little better than trucks of the same weight. And if the heavy cars actually ride so well why bother to give them knee-action wheels the same as the cheaper light cars?

The truth is that automobiles do not represent the wonderfully progressive engineering we like to shout about. Sales departments demand talking points and talk about "sensing the trend of customers' desires," before they are even known by themselves. Aside from the desire for efficient locomotion in reasonable comfort, most of the "demands" for multi-cylinders, octane selectors, ride controls, free wheeling and the like have come from sales department propaganda, not from the public.

Now we are being told of the wonderful advantages of knee action. Assuming it is all that is claimed why has it taken our progressive engineers so long to find its advantages, for "knees" of various kinds have been used in Europe for the past five or ten years.

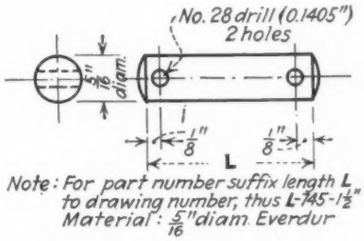
Considering the handicaps imposed on the designers by sales, by body designs and by costs departments, they have done fairly well. But why they still put out cars in the middle or higher class that require grease gun connections at a dozen inaccessible places, is a mystery. And some of the new "knees" add perhaps a dozen more grease gun fittings. And while the service station man can reach these oil holes, he sometimes misses a few. The skirted fenders and wheel covers add to the inaccessibility of parts.

—Frank C. Hudson,
New York, N. Y.

Drafting Short-Cuts

Harold L. Wynn
Executive Engineer
Pacific Electric Manufacturing Corporation

Applying to such parts as studs, bolts, bars, rivets, special washers and other general components, the drafting method shown in the accompanying illustration is particularly useful. It is especially useful in listing lengths of standard parts that are normally carried in stock, in addition to which it eliminates a great deal of drafting time. Experience with this method



Where length is the only variable drafting expense is reduced by using this type of drawing

over an extended period also demonstrates that it is of considerable assistance in formulating bills of material. It should be noted, however, that variations of finish, material and size cannot be listed, so that it is necessary to prepare separate drawings when these variables exist.

A Proper Criticism

To the Editor:

Criticism of M. G. Van Voorhis' chart for the modulus of a rectangle section at angle α, as outlined last month, is not that the formula is an incorrect calculation of the value $Z = I/y$ if defined in the usual way, but that it is incorrect to use this modulus in the same way as for a principal axis by means of the usual equation:

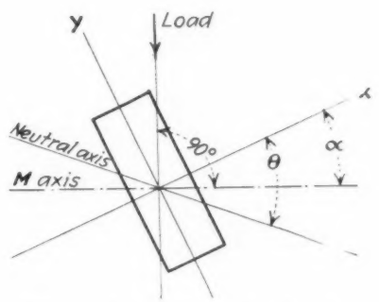
$$Stress = \frac{bending\ moment}{section\ modulus}$$

This question is discussed in complete detail in Boyd's "Strength of Materials," third edition, Appendix B, page 412. As illustrated in the accompanying diagram where θ, the angle made by the neutral axis of bending, is not the same as the angle α, the axis of bending moment, the maximum stress S is given by the following equations in which Z agrees in form with that given by Mr. Van Voorhis:

$$S = \frac{M \cos(\theta - \alpha)}{Z}$$

For inclined loading, if the angle θ of the neutral axis is used, it is permissible to use the usual stress equation. In general, however, this method is not very convenient as the angle α will usually be the known quantity, while the angle θ will have to be calculated. Undoubtedly, many engineers fall into the error suggested by this criticism. Handbooks that publish such formulas without adequate explanation, and most of them do, are open to criticism on this account.

—H. R. Lloyd
University of Michigan



Where the angle made by the neutral axis of bending is not the same as the angle of the section axis the usual stress formula cannot be used

To the Editor:

Mr. Lloyd's criticism is accepted, and it is regretted that the modulus as determined from the chart published in the December, 1933, number cannot be used in a more simple manner. The error which would be introduced by improper use of this chart is on the safe side but would likely be too large for satisfactory use.

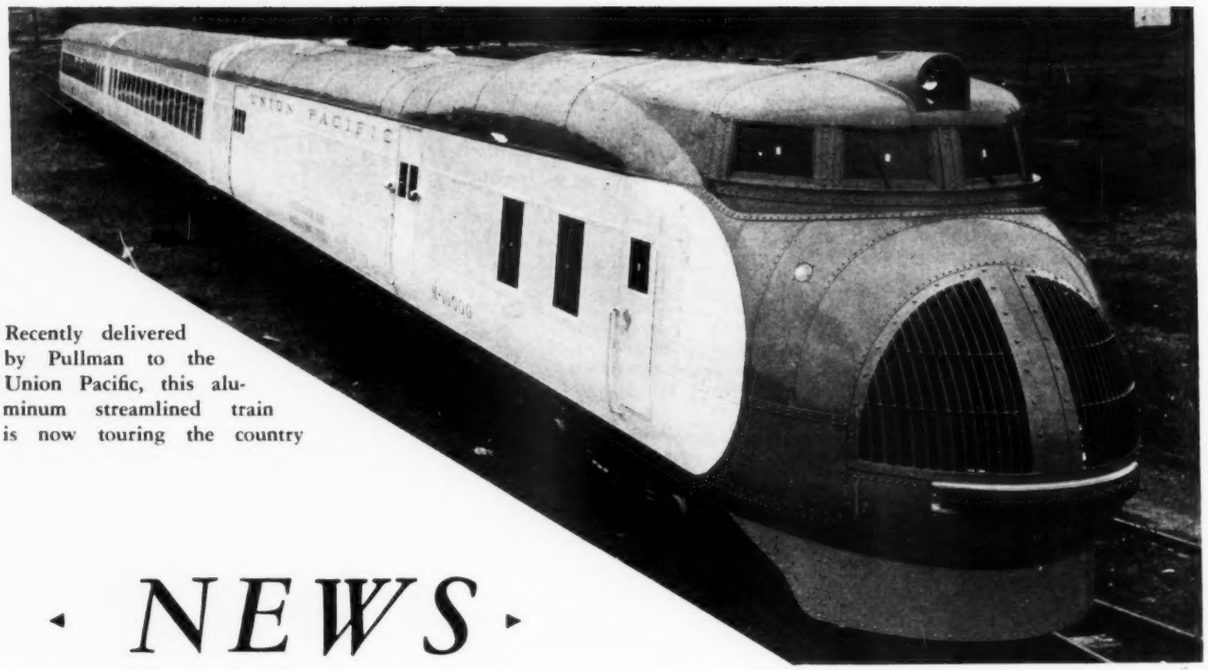
—M. G. Van Voorhis
South Euclid, Ohio

Improved Style or Performance

Harry E. Cohen
New York, N. Y.

Too much emphasis is placed on the style phase and not enough on improving the basic appeal on which a product is bought. In an appliance, for example, the importance of style must not be belittled, but more effort should be made to learn consumers' reactions regarding the usefulness, design and performance of the device. The manufacturer can by careful analysis of the work of service men determine what is basically wrong with the product. This practice would insure a successful marketing policy as it would make certain that the product is designed to fulfill the functions for which it is intended.

A common practice is to redesign the product constantly, making new models for the express purpose of "showing the trade something new each year." This practice, while a temporary stimulant, represents a wasteful form of distribution because it unnecessarily increases the cost of the product and passes an increasing cost on to the consumer.



Recently delivered by Pullman to the Union Pacific, this aluminum streamlined train is now touring the country

· NEWS ·

More Streamlined Trains

Several additional 3-car streamlined aluminum trains are being built by the Pullman Car Manufacturing Co. according to Mr. M. P. Winther of the Pullman Company. It is stated that these new 3-car units will be identical to the train recently delivered to the Union Pacific Railroad.

The New York, New Haven & Hartford Railroad is also reported to be considering the use of high-speed streamlined trains for main line service. Although details of the type of train, its size and passenger capacity are not yet known, Mr. John J. Pelley, president of the New Haven announced that bids have already been asked for the streamlined train.

Researches in Alloys for Watch-making

Despite the variety of alloys used in watches, clocks and similar instruments, this industry has been singularly lacking in metallurgical advances, the alloys used having remained the same for many years.

In an effort to improve and standardize the metals used in this industry, the Elgin National Watch Company is sponsoring a research project at the Battelle Memorial Institute to study the metallurgy of watch-making. Having already developed the manufacture of its own parts, rather than relying on foreign sources, the Elgin company is in a position to fully utilize metallurgical research developments and to work out new alloys especially fitted to meet the particular requirements of their industry.

Copper Resists Soil Corrosion

Copper and alloys high in copper appear to corrode less rapidly than ferrous materials in practically all soils, according to a recent report from the Bureau of Standards. All commonly used ferrous materials were found to corrode similarly underground, the soil characteristics being the most important factor in determining the amount of corrosion. Metallic coatings appeared to have reduced the rates of corrosion, but a number of specimens developed rust spots after extended exposure. A complete report of this study is given in Research Paper No. 638 in the *Bureau of Standards Journal of Research* for January 1934.

Measurement of Split Seconds

Visual instantaneous indications of extremely brief time intervals are now obtainable with a new high-speed timing device. Operating on the principle of dividing one cycle of a 60 cycle wave into sixty, a hundred or even a thousand parts, elapsed time of almost any brief event can be measured. For example, the fraction of a cycle required for a high-speed relay to operate, the time of an operator to apply automobile brakes after receiving a signal, the reaction time of an individual during psychological studies, can all be determined.

Developed recently by Westinghouse engineers, this timer can take any one of several different forms for dividing one cycle of a 60-cycle wave into 60 parts. One method uses a synchronous motor-driven disk, rotating behind a shield. On the disk numbers from zero to sixty are cut through at the periphery and as the disk rotates the numbers pass before a viewing slot in the shield. Behind the disk, in line with the slot, a neon light is arranged to flash at the end of the period under observation.

For applying this device to measure the time required for a high-speed relay to operate, while the disk is being driven at one revolution per second by a 60-cycle synchronous motor, a switch is closed. The circuit is so arranged that the high-speed relay is energized at the exact instant the zero on the disk passes by the viewing slot. The neon lamp is then energized at the exact instant when the relay has completed its operation. A number is illuminated by the extremely brief but high intensity flash, thereby indicating the time of operation of the relay. Although the number is seen only perhaps for a thousandth of a second, the persistance of vision makes the number easily recognizable. For example, the number 17

appearing indicates the relay operated in 17/60 of one cycle.

This device has been found invaluable by Westinghouse for use in designing high-speed relays, but it has not as yet been made commercially available.

Automotive Engineer Conjectures on Efficiency

Further improvements in automobile design were suggested by E. H. Shepard, of the Chevrolet Motor Company in a paper, "The Economy Fallacy," read at the annual meeting of the Society of Automotive Engineers. Quoting Mr. Shepard's closing remarks:

"Suppose that 80 or 90 per cent of the motor friction was eliminated by removing piston ring drag, by using needle bearings on all rotating surfaces, and by reducing friction on push rod tappets and cams. Suppose that some way was found to use the heat now wasted in the water jacket and exhaust system.

"After this we could devise a satisfactory constant compression engine so that pumping losses would be all but eliminated, and the part-throttle thermal efficiency doubled. By mounting this engine in a car with rolling resistance reduced by ball bearings, using a new form of tire with flexible tread and sidewalls, with a body that was truly streamlined, we could get such an increase in miles per gallon . . ."

Mr. Shepard's remarks indicate that there is still room for further improvements in automobile performance. But in the light of present knowledge, to what extent are these conjectured improvements visionary?

Sodium Lamps Reduce Eye Strain

Radiating nearly all of its light in the yellow part of the spectrum, the sodium arc is essentially monochromatic although the presence of a small amount of neon as a "starting gas" makes the average color a light orange. In contrast, light from the sun or from an incandescent lamp is composed of all of the colors in the spectrum as shown in a recent article in *Product Engineering* for December 1933, page 465. Although light from an incandescent lamp is apparently yellow in tone, actually all colors—violet, blue, green, yellow, orange and red—are present.

One of the limitations of the human eye is its inability to form sharp imagines when the object has several colors. The blue rays come to a focus a little ahead and the red rays a little behind the retina. For this reason it is impossible for the eye to form a sharp imagine of an object showing two or more colors.

Eye-strain attending close work under ordinary light is in part the result of the effort of the lens to bring all colors into sharp focus at the same time. The lens cannot accomplish this, but it never stops trying, and this constant effort leads to eye fatigue. Such wasted effort does not occur with monochromatic light, and continued close work becomes possible. The sodium arc, with its greater acuity, combined with the fact that its color is at the point of maximum sensitivity of the eye, makes the sodium lamp extremely useful under conditions where fine detail must be observed.

New High-Strength Bronze

From reports of recent tests, a new age-hardening bronze casting alloy containing 6 per cent nickel, 6 per cent tin and 88 per cent copper opens up new possible uses for non-ferrous castings. This alloy when heat treated develops a Brinell hardness of 200, with an ultimate strength of 100,000 lb. per sq.in., a yield strength of 82,000 lb. per sq.in., a proportional limit of 60,000 lb. per sq.in., and 10 per cent elongation. This compares with an ultimate strength of 40,000 lb. per sq.in. and a proportional limit of 12,000 lb. per sq.in. for the standard bronze material. The new alloy costs no more than the standard 88-10-2 bronze.

As explained by E. N. Wise and J. T. Eash in an article, "Strength and Aging Characteristics of the Nickel Bronzes," in *Metal Technology* for January, 1934, the age-hardening is caused by the precipitation of a phase containing an equal weight of nickel and tin. By properly adjusting the heat-treatment, a selected combination of properties can be secured in heat-treated castings of this alloy. The authors point out that these unusual properties can be readily secured with present foundry technique.

Teague Selected by Ford

For the Henry Ford Building at the Century of Progress, Walter Teague has been awarded the contract for setting up the exhibit and decorating the interior of the building. With a floor area of 11 acres, this building, 800-ft long, will be the largest on the grounds. A central cylindrical section, capped by a dome, will house Ford's historical exhibit covering the development of modern transportation methods from the time of the chariot. In a hall 500x170 ft. will be Ford's demonstration of how the earth furnishes such materials as rubber, minerals, asbestos and soya beans used in making his automobile. The arranging of these exhibits, and the interior decorations for the entire building will be under the direction of Mr. Teague.

Industrial Art Exposition Opens April 3

Preparation of exhibits for the Industrial Art Exposition will be completed in time to open the exhibition on April 3, according to Alon Bement, director of the National Alliance of Art and Industry. The exhibit will occupy 25,000 sq.ft. of floor space on the 63rd floor of the R.C.A. Building. There will be two groups of exhibits, one devoted to industrial materials, and the other to manufactured articles.

Exhibits of articles are restricted to those originated by the designer displaying them. Each article must be intended for quantity reproduction and must bear a manufacturer's name. Within these limitations, articles already entered cover the range from percolators to perambulators, from china and glass to railroad trains, from alarm clocks to draperies and furniture, and from refrigerators to oil-burners.

European Applications of Nickel Alloy Steels

Numerous interesting applications of alloy steels as practiced in Europe include the use of a nickel-chromium-molybdenum steel for switches and cross-overs in mine trackage. Besides having a high resistance to abrasion, this alloy is weldable, machinable and has a high elastic limit. After air-quenching, and depending on the drawing temperature, it has an ultimate strength of 125,000-240,000 lb. per sq. in., an elastic limit 105,000-200,000 lb. per sq.in., elongation 6-16 per cent, and Brinell hardness 275-450. It is reported that thousands of frogs made of this steel have been in use over a period of six years under heavy traffic conditions and have been highly satisfactory.

Other European uses of alloy steels include nickel-chromium steels for vibrating screens; gears, pins and buckets of steam shovels; and in

briquette presses. It is reported that in a series of tests the life of a balance shaft made of 2 per cent nickel steel and heat-treated was three times as long as that of a similar shaft made of ordinary semi-hard carbon steel. For air compressor valves exceptionally good results have been obtained by using a 3½ per cent nickel.

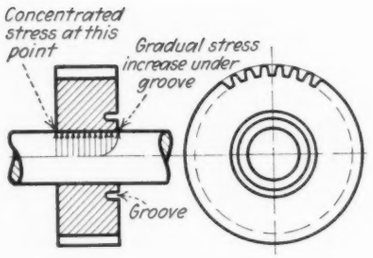
A good idea of the extent to which some English manufacturers use alloy steels can be gained from the fact that the internationally known firm of Holman Bros., Ltd., of Camborne design machines wherein 80 per cent of the machine is made of various alloy steels of 3-5 per cent nickel. Similarly a well known French manufacturer of hammer drills makes relatively equally extensive use of 3.5 per cent nickel steel quenched in oil or 3 per cent nickel steel case hardened and quenched. For the pistons of concrete breakers which must be hard and shock resistant, this same company uses a case hardened 4.91 per cent nickel—0.53 per cent chromium alloy.

Weathered Copper

Service tests indicate that the process of quickly producing a weathered effect on copper is now out of the laboratory stage, according to William M. Crane, Jr., of the Copper & Brass Research Association. By this method copper roofs and other sheet copper work may be made to turn a beautiful green within a few hours. This artificial weathering is produced by spraying on the metal five or six applications of ammonium sulphate which, upon subsequent washing with water, produces a green coating over the copper.

Shrink-Fit Stresses Responsible for Fatigue Failure

Investigations to determine the cause of a number of failures of axles in railroad service indicate that the stresses produced by pressing or shrink-fitting a wheel or gear hub reduce the fatigue strength of the axle. According to information given by A. V. de Forest at a recent meeting of the Institute of Aeronautical Sciences held at Columbia University, the reduction in fatigue strength may be as much as 40 to 60 per cent. Experiments made to find out how to overcome this condition have revealed that the stress concentration at the edge of the pressed-on hub can be reduced as much as 75 per cent by cutting a deep groove in the face of the hub, as shown in the accompanying illustration. Elastic deflection of the



Showing how a groove in the face of a pressed-on gear gives a more uniform distribution of the press-fit stresses, greatly increasing the fatigue strength of the axle

portion of the hub between the groove and shaft causes a gradual instead of an abrupt change in shaft stresses at the edge of the gear.

At the same meeting, C. F. Nagel, Jr., chief metallurgist of the Aluminum Company, explained the properties of the new age-hardening 24S aluminum alloy, which has larger proportions of the same alloying elements as the duralumin material. Although this new 24S alloy has no higher fatigue strength than dural, it does have 20 per cent greater yield point. Mr. Nagel also stated that spot welding methods using large currents for a short length of time have been successfully applied to Alclad material, joining the two pieces without affecting the corrosion-resisting properties of the aluminum surface. Such welds are said to have the same corrosion resistance as the unwelded material. To satisfactorily control the short-time interval so that uniform welds could be produced, electronic time control is necessary.

MEETINGS

American Society for Testing Materials—Annual meeting, Chalfonte-Haddon Hall, Atlantic City, June 25-29. R. E. Hess, assistant secretary, 260 South Broad St., Philadelphia, Pa.

EXHIBITIONS

National Alliance of Art and Industry—Industrial Arts Exposition, R.C.A. Bldg., New York, N. Y., April 3-30. Alon Bement, director, 30 Rockefeller Plaza, R.C.A. Bldg., New York, N. Y.

National Oil Burner Show—Commercial Museum, Philadelphia, Pa., March 5-9. Harry F. Tapp, secretary, American Oil Burner Association, 342 Madison Ave., New York, N. Y.

Packaging Exposition — Hotel Astor, New York, N. Y., March 13-16. American Management Association, 232 Madison Ave., New York, N. Y.

Design Trends in Heating Equipment

At the Heating and Ventilating Exposition, held in New York, February 5-9, there was a marked increase in the number of domestic heating units with a furnace specially designed for oil burners. The entire unit is inclosed in a casing with smooth outer surfaces, and is usually enameled in color. In oil burner units the evident trend is toward a greater use of standard purchased parts such as pumps, relief valves, nozzles, fans and electric motors.

Most of the oil burners exhibited were of the "gun-type" with the electric motor direct-connected to a shaft carrying the blower fan and oil pump. Considerable ingenuity was displayed in arranging the units to form a balanced design on each side of the air-blast tube. Enamel or lacquer exterior finish in red, black and other colors predominated, while several units were finished in a glossy vitreous enamel in bright colors. Nearly all the oil burners had screens of Monel metal and nozzles of hardened stainless steel.

In air-conditioning devices tinned copper is the material most used for heating or cooling coils, with fins employed in some devices to increase the cooling surface. An aluminum corrosion-resistant alloy is used in one brine-spray cooler. For hot-water coils inside of steam boilers, one manufacturer uses extruded seamless copper tubing with joints silver-soldered. This tube coil is sealed into the steam boiler by means of a lead gasket.

Space limitations in air conditioning apparatus usually make it necessary to apply a small high-speed electric motor to drive a relatively slow-speed compressor or pump with a short center distance between the motor and pump shafts. For this drive V-belts are in general use, having as many as four or five belts in the larger capacity units. A new type of leather belting on display, subjected to a special treatment in addition to the ordinary tanning process, was said to give greater grip and was claimed to be suitable for short center drives, even with small arcs of contact.

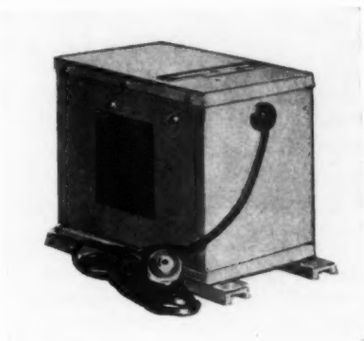
In the effort to reduce noise, electric motor manufacturers had on display several new resilient motor mountings as well as motors with special windings and new electrical designs.

Air filtering devices made use of sheet felt, cotton fabric, and a new glass material in fibrous form.

NEW MATERIALS and PARTS

Delta Automatic Voltage Regulator

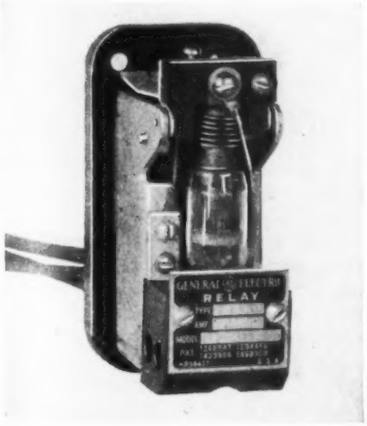
Operating by changing voltage relations between the windings of two transformers, regulator provides a stable voltage output with variations as high as 25 per cent in voltage supply, operating with negligible time delay.



Has no relays and other moving parts. Designed to maintain an output voltage variation within plus or minus 1 per cent with a load of approximately unity power factor, and available in special designs for equal performance with load power factors other than unity. Stock sizes are made for 95-130 volt input in power ratings of 60 watts as shown, and also in ratings of 120, 250, and up to 2,000 watts output. Delta Mfg. Co., 29 Osborne St., Cambridge, Mass.

G.E. Vacuum-Contact Relays

Designated as Type HBA for use in atmospheres that may contain explosive gases such as in coal mines, oil refineries, flour mills and grain elevators. Inclosed in a steel container,



relay has single-pole, double-throw contacts located in a heavy-wall glass tube from which air has been removed. A movable arm passing through a metal bellows at one end operates a moving contact between two stationary contacts within the tube. Contacts rated at 15 amp. continuous, 10 amp. interrupting, at 115 and 230 volts, a.c. or d.c. Case is $2\frac{3}{32}$-in. wide, $4\frac{3}{32}$-in. high, $2\frac{15}{16}$-in. deep. General Electric Co., Schenectady, N. Y.

Lunkenheimer Constant Level Oiler

Designed to automatically maintain a constant oil level in ring-oiled bearings or anti-friction bearings with oil bath lubrication. The device operates on the liquid seal principle, feeding only when the oil level in the bearing drops below the end of the shank, breaking the liquid seal and permitting air to enter the bottle. Adjusting collar gives a vertical adjustment range of $\frac{1}{2}$ in. in oil level. To refill, bottle

is lifted out of the tee fitting without disturbing any connections, so that spare bottles may be filled and substituted for empty ones. The Lunkenheimer Co., Cincinnati, Ohio.

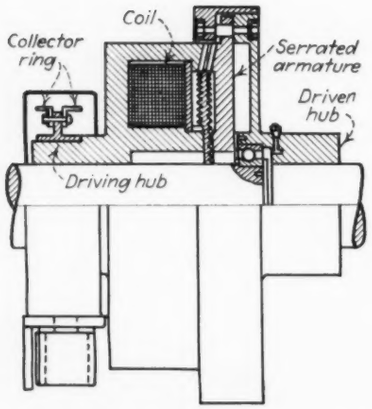
Waldron Coupling

For heavy-duty direct-connected or geared motor and engine drives, this coupling is designed for heavy loads, large misalignments, heavy shock and vibration service. Coupling consists of two identical hubs with external teeth, each hub meshing with a torque ring consisting of a solid steel ring with teeth cut on the inside and outside. Torque rings mesh with the outer case

and are held loosely in place by the bolted-on end plates. End plates serve only to seal the coupling from dust and moisture, and to retain the lubricant. The addition of the torque ring provides engagement at four points at which relative movements between the engaging teeth can take place. Since hubs are identical, they can be interchanged when teeth become worn to provide new driving surfaces. Likewise, torque rings can be reversed to provide new driving surfaces. Available in fifteen regular sizes for shafts from $1\frac{7}{8}$ to 12 in. diameter, with ratings from $22\frac{1}{2}$ hp. to 4,840 hp. per 100 r.p.m. Smith & Serrell, 7 Halsey St., Newark, N. J.

Dings Magnetic Clutch-Coupling

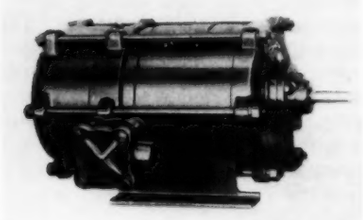
Combining a magnetic clutch and a positive mechanical coupling, the contact surfaces have serrated V-tooth faces, designed so that engagement is instantaneous over the entire face. Pilot bearing on the shaft is supported on a ball bearing. Adaptable for synchronizing the speed of direct current motors, for use with mill "screwdowns" or wherever positive mechanical engagement with magnetic operation is desired. Magnetic coil is form wound and vacuum pressure impregnated. Slip rings and brush holders are protected by a housing. With this construction the coupling is said to transmit six times as much power as a friction clutch of the same diameter and current consumption. Available in sizes ranging from 12 in. requiring 150 watts and transmitting 20 hp. at



100 r.p.m., to a maximum size of 48 in., 1,500 watts, 2,660 hp. at 100 r.p.m. Dings Magnetic Separator Co., Milwaukee, Wis.

Louis Allis Explosion-Proof Capacitor Motors

Designed especially for use in all Class I, Group D hazardous locations, this line of single-phase capacitor motors has the condenser inclosed in the motor. A positive-acting switch is used to cut out the capacitor at a predetermined speed. Available in a nonventilated type with ratings from ½ to



1 hp., and in a totally-inclosed fan-cooled type from 1½ to 3 hp. Can be connected externally for either 110 or 220 volts. The Louis Allis Co., Milwaukee, Wis.

Mercury Thermoregulator

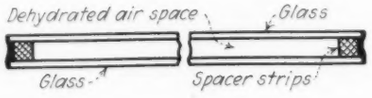
Consisting of a sealed large-bulb, small-stem type mercury thermometer having electrical contacts sealed into the stem to close an electrical circuit when the mercury column contacts both electrodes. To set the regulator, the bulb is immersed in liquid at the temperature to which the regulator is to be set, and the surplus mercury is spilled off into a sealed-in side reservoir. This sets the temperature of operation within 0.02 deg. C., holding the temperature within a range of plus or minus 0.01 deg. C. A recess above the stem holds enough mercury so that a 20 deg. C. overshoot in temperature does not affect the setting. Designed for use with sensitive relays requiring no more than 10 milliamperes operating current. Can be adjusted for any temperature from minus 30 deg. to 300 deg. C. American Instrument Co., 774 Girard St., N. W., Washington, D. C.

Bruning Erasing Machine

Designed to be held in the fingers like a pencil which enables operator to maintain accurate finger control when erasing pen or pencil lines from tracings or drawings. Machine is operated by a self-contained electric motor operating on either a.c. or d.c., 110 volts. Supplied with an assortment of pen and pencil erasers. Charles Bruning Co., Inc., 102 Reade St., New York, N. Y.

Thermopane Insulated Glass

Made for use as windows to reduce heat transmission and condensation. Is a form of double glazing having a sealed-in air space containing dehydrated air. Air is sealed in by special bonding materials and methods said to produce an air-tight, water-tight and dust-proof unit. Is built to dimensions as required; cannot be cut on the job. Furnished with ⅛ or ¼-in. air space as standard, and available with ½-in. space for special applications. Product is made from flat glass of any type carrying at least one flat smooth surface. For use in wooden frames, or



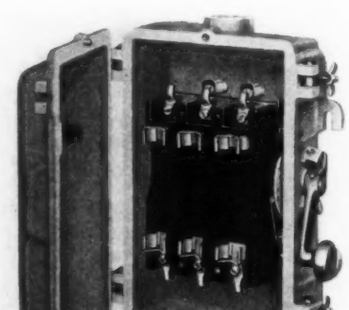
in lead, zinc and steel bars. Can be supplied in rectangles, or special shapes with straight or curved outlines. Material with ¼-in. air space is said to transmit but 47 per cent as much heat as a single glass window. Charles D. Haven, 3508 N. Oakland Ave., Milwaukee, Wis.

Larger Sundstrand Pump

Rotary pump with positive displacement is designed for pumping fluids at high pressure. As described in this section of the June number, rotor and roller revolve with each other and are carried in roller or needle bearings. Pump is said to develop high volumetric efficiency because of the self-emptying design of the pumping members. Now available in two larger sizes, 1 and 2 gal. per min. at 1,725 r.p.m. Sundstrand Machine Tool Co., Rockford, Ill.

Cast-Iron Switch Inclosures

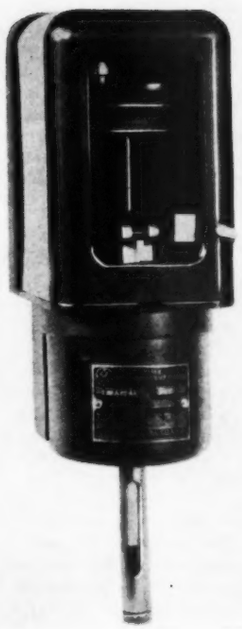
Having the same features as the maker's 50,000 series, this line with cast-iron inclosures embodies quick-make and quick-break elements with interlock and readily removable base elevated from the back of the box to facilitate wiring. Box is said to be dust-tight and weatherproof. Available in 30- and 60-amp. types, 2 and 3-



pole, 3 and 4-wire, fusible and unfused, for both high and low voltage. Square D Co., 6060 Rivard St., Detroit, Mich.

G.E. Plunger-Type Relays

Instantaneous and time-delay plunger-type relays, for protection against overcurrent and undervoltage and for use as auxiliary relays, depend upon the action of a magnet coil in attracting or releasing a plunger at predetermined values of voltage or current. Adjustments and convertible features, combined with single-pole design, permit changing the overcurrent relay from time delay on contact opening to



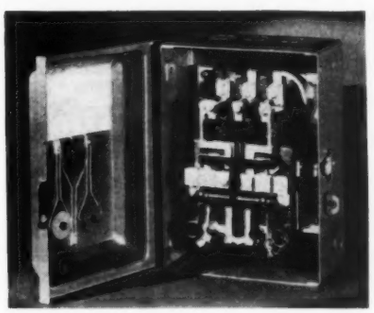
time delay or contact closing, or both, by a convenient adjustment. Air intake to the bellows can be regulated to change the time delay in opening or closing contacts. Bellows is made of rubber which is said to be unaffected by high or low temperature. Device requires no lubrication. General Electric Co., Schenectady, N. Y.

Vickers Balanced Gear Pump

Designed with inter-connected balancing chambers so that each gear is always in hydraulic balance, thus eliminating thrust loads and consequent wear on bearings, gears and housings. This design is said to result in longer life, higher efficiency and to allow the use of higher operating pressures. When used either as pump or motor, it cannot bind or lock, and as a motor it can be started under full pressure having full torque when stalled. Rotation is reversible without the necessity of disassembling. Available as a pump for pressures up to 1,500 lb. per sq.in. for driving machinery such as drills and grinding spindles. Supplied in a wide range of sizes. Vickers, Inc., Detroit, Mich.

Square D Motor Starter

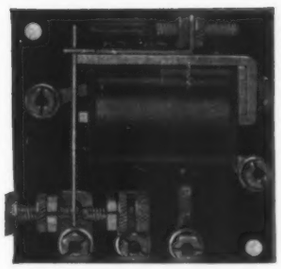
Solenoid type of automatic motor starter has a vertical, straight-line action and cannot be accidentally closed by vibration. Has no flexible leads. Double-break contacts are silver. Insulating base and arc barriers are



porcelain, which does not carbonize nor readily collect dust. Design incorporates thermal overload relays which are mounted on the front of the panel and are readily interchangeable. Large pushbuttons on the cover are 1 in. in diameter. To provide ample wiring space, cabinet is 9$\frac{5}{16}$-in. high, 7$\frac{1}{2}$-in. wide including latch, and 5$\frac{1}{8}$-in. deep including reset button. Designated as class 8532 Type F, starter has maximum polyphase ratings of 5 hp. 220 volts, 7$\frac{1}{2}$ hp. 440-550 volts. Also available with a four-pole contactor for two-phase service. Square D Co., Industrial Controller Div., Milwaukee, Wis.

Ward Leonard Sensitive Relay

Single-pole, double-throw relays designed for direct current operation, especially for photo-electric and electronic applications using low current values. Designed to provide a high sensitivity at low induction, good contact torque at pull-up, and a constant drop-out that can be adjusted up to 85 per cent of the pull-up value. These features are said to result from the use of a nickel alloy in the magnetic circuit. The relay, assembled on a bakelite base 2$\frac{1}{2}$x2$\frac{1}{2}$ in., can be mounted in any position. Knurled heads are provided for screws adjusting silver contacts and spring tension on the armature. Designed for operation on appproximately 14 milliwatts; when closer adjustment of contacts is permissible operates on half this power.



Contact rating 0.75 amp. 115 volts d.c., 1.5 amp. 110-220 volts a.c. Available with operating coils of 0.5 ohm and 162 milliamperes, up to 31,000 ohms and 0.65 milliamperes with eleven intermediate capacities. Ward Leonard Electric Co., Mount Vernon, N. Y.

E.C.& M. Magnetic Starter

Oil-immersed, across-the-line, combination magnetic starters announced in December 1933, p. 476, are now available for motors up to 30 hp. 220 volts, 60 hp. 440 volts, and 75 hp. 550 volts. Design features described in the earlier announcement are embodied in these larger sizes. The Electric Controller & Mfg. Co., 2700 East 79th St., Cleveland, Ohio.

Foxboro Controller

Supplied in a case adaptable to either flush or surface mountings; connections may be made at top, bottom or back. Working parts are mounted on a cast aluminum base with the cover

removable from the front, leaving interior open for inspection. Adjusting dial on the lower face of the controller operates control valve, while indicating gage above the knob shows air pressure on the diaphragm of control valve. Indicator dial, 2 in. diameter, also shows whether valve is opening or closing. Available either as a temperature controller or pressure controller to operate a valve-motor. The Foxboro Co., Foxboro, Mass.

NEW BOOKS and PUBLICATIONS

Industrial Radiography

Ancel St. John and Herbert R. Isenburger. 232 pages, 6x9 in. Red clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $3.50.

Two recognized experts in industrial applications of X-rays discuss practical uses of radiography in a concise manner, without the usual scientific and theoretical atmosphere.

Seven introductory chapters take up the development of X-ray equipment and the properties of X-rays, describing industrial uses for X-ray apparatus with emphasis on the economic possibilities. Detailed instructions follow on steps in making radiographs and interpreting them, with special treatment regarding large castings and forgings, and welded vessels. Tables, charts and a bibliography of 426 references, followed by an index, make up the last section of the text.

To the designer whose ability is cramped by failure of foundry or welding shop to produce sound products, this test indicates the possibility of using X-ray to improve shop processes and enlarge the field of the designer.

Complete cost data is given for several different types of radiography equipment, including space requirements, floor plans and auxiliaries such as photographic apparatus and safety equipment.

Inventions, Patents and Trademarks

Milton Wright. 310 pages, 5½x8 in. Red clothboard covers. Published by McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $2.50.

In this second edition, a revision of "Inventions and Patents," the text has been brought up-to-date with recent laws and regulations and new chapters added on design patents, trademarks, prints and labels, copyrights, and damages and accounting. The reviewer believes that this book will appeal to engineers because of the understandable style in use throughout in discussing legal matters. Also, the author's practical attitude, especially in later chapters on patent promotion will appeal to engineers.

As in the first edition, the text is concluded with a question and answer section and a series of model contract forms. In addition, the new volume has a set of rules on drawing up a royalty contract. Employee relations in regard to patents are clearly explained, as well as patent procedure and pit-falls. This book should be found valuable to the designing engineer.

A.S.T.M. Tentative Standards

1,136 pages, 6x9 in. Paper covers. Published by the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. Price $7.

All tentative specifications, methods of test and definitions of terms issued by the A.S.T.M. covering engineering materials are included in this 1933 publication. Of the 223 tentative standards included, 47 are published for the first time, and 41 were revised in 1933. New tentative standards cover mild steel plates, alloy-steel and carbon-steel castings, elliptical springs, while standards for aluminum, aluminum alloys, zinc base die-castings, insulated wire and cable are among those revised. Included is a subject index and two tables of contents to facilitate the use of the book.

Symposium on Cast Iron

164 pages, 6x9 in. Paper covers. Published by the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. Price $1.

Concise data on the composition, metallurgy, properties and applications of many grades of cast iron are given in this publication, sponsored jointly by the American Foundrymen's Association and the American Society for Testing Materials. In the section on metallurgy the effects of the various elements in cast iron, its structure and the influence of mass and thermal history are given briefly. Of special interest to the designing engineer is the 80-page chapter on properties, including data from many sources on gray and white cast irons. Physical constants and mechanical properties are given, as well as data on creep, damping capacity, effects of elevated temperatures, machinability and wear, corrosion and heat resistance.

Other sections are devoted to specifications, heat-treatment, foundry practice and welding.

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Stress Analysis by Photo-Elasticity

Including five articles that appeared recently in *Product Engineering*, this 12-page reprint describes polariscopes, methods of analysis, typical design problems solved by photo-elasticity and a discussion of the scope of this method. Other published work of the Columbia Photoelastic Laboratory is listed in a bibliography included in the booklet. Copies can be obtained from A. G. Solakian, Physics Building, Columbia University, New York, N. Y. Price 25 cents.

New Departure Ball Bearings

Dimensions, load data and list prices on their entire line of ball bearings are given in the ninth edition of "New Departure Ball Bearings," a 128-page, 5½x8½-in. handbook in heavy paper covers. New price lists for double-row bearings, several new bearing types and added sizes are announced in this edition. Two pages preceding the data sheets for each of the bearing types give their design and load characteristics, and typical mountings. This information, pointing out the outstanding features of the various types of bearings, will be of assistance to the designing engineer in selecting the type of bearing to best suit his requirements. More than 40 pages comprise a section devoted to data on bearing selection, tolerances and fits, standard locknuts and lockwashers, tables of the equivalent bearings of different makes, and tables of bearing weights.

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Capacitors—The Ideal Electric and Mfg. Co., Mansfield, Ohio. Bulletin 710, 8½x11, 16 pages, "Ideal Capacitors for Power Factor Correction," includes a brief explanation of power factor and how the capacitor acts to correct low power factor.

Electric Motors—The Emerson Electric Mfg. Co., 2018 Washington Ave., St. Louis, Mo. Folder, 4 pages, "Improved Split Phase Motors," includes data on design features and performance.

Photo-Elastic Equipment — Central Scientific Co., 460 East Ohio St., Chicago, Ill. Article, "New Uses for Light Waves" in the December, 1933, number of their house organ, *Cenco News Chats*, includes a price list of the parts necessary for a simple polariscope, and briefly describes methods of photo-elastic analysis.

Relays—Struthers Dunn, Inc., Philadelphia, Pa. Catalog B, 24 pages, 8½x11, "Dunco Electrical Control Equipment," gives catalog information on various types of special and general purpose relays, along with wiring diagrams, ratings, applications, and coil and contact data.

Screws and Nails — Parker-Kalon Corp., 200 Varick St., New York, N. Y. Catalog, 8½x11, 36 pages, "Parker-Kalon Products." In this revised edition, is shown applications and advantages of self-tapping metal screws, capscrews, drive screws, screw nails, wing nuts and thumb screws. Stock sizes and methods of application also included.

Shaft Diameter for Torsional Deflection

A. D. McKENZIE
The Ohio Brass Company

Formula

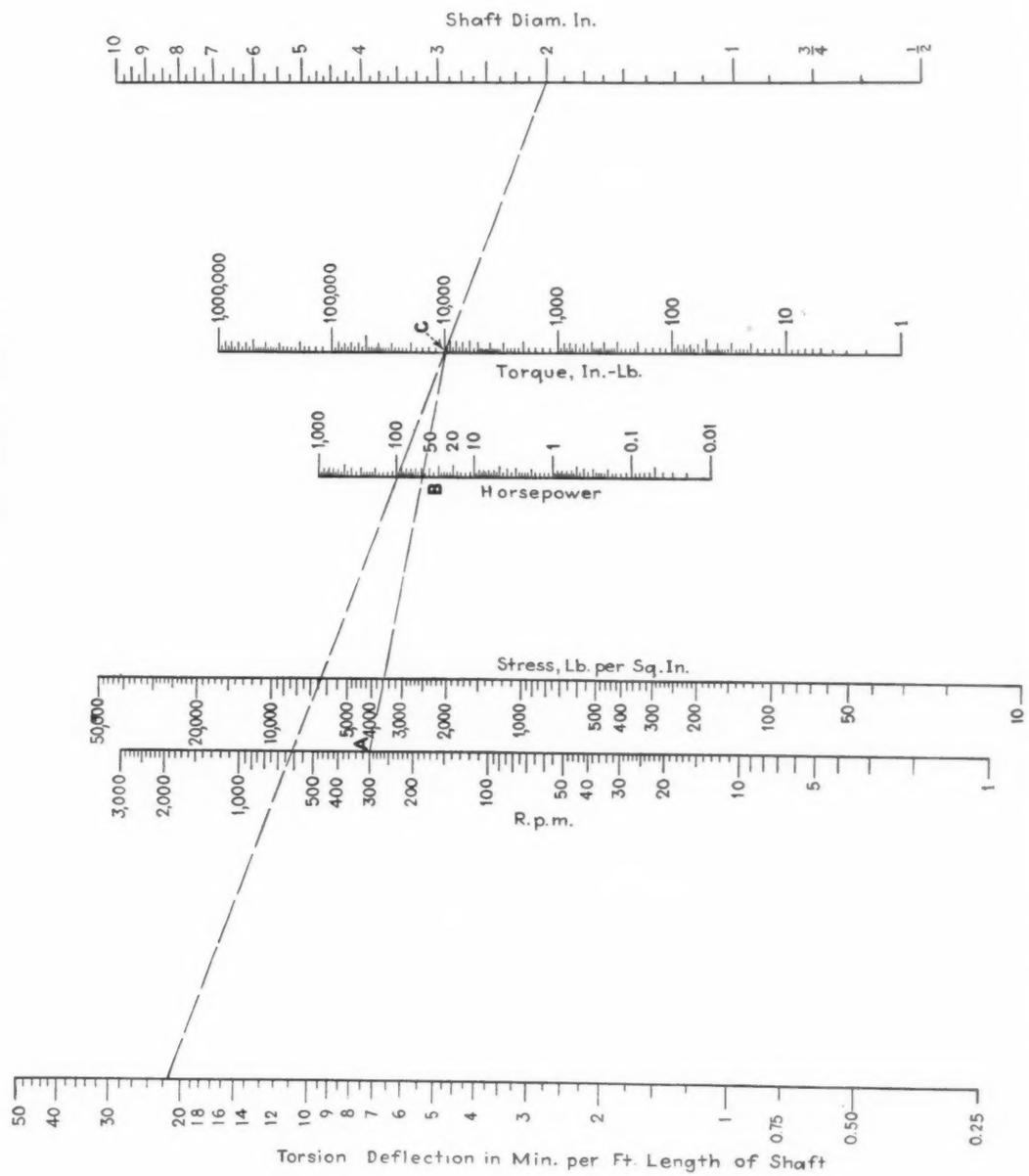
$$T = \frac{63{,}100 \times hp.}{R.p.m.}$$

$$S = \frac{Torque \times 5.1}{D^3}$$

$$Deflection\ (min.) = \frac{Torque \times 0.35}{D^4}$$

Example:
For 50 hp. at 300 r.p.m. draw line **A-B**, extending it to **C**. Any line through **C**, cutting the deflection, stress and shaft-diameter scales will give the numerical values of those factors

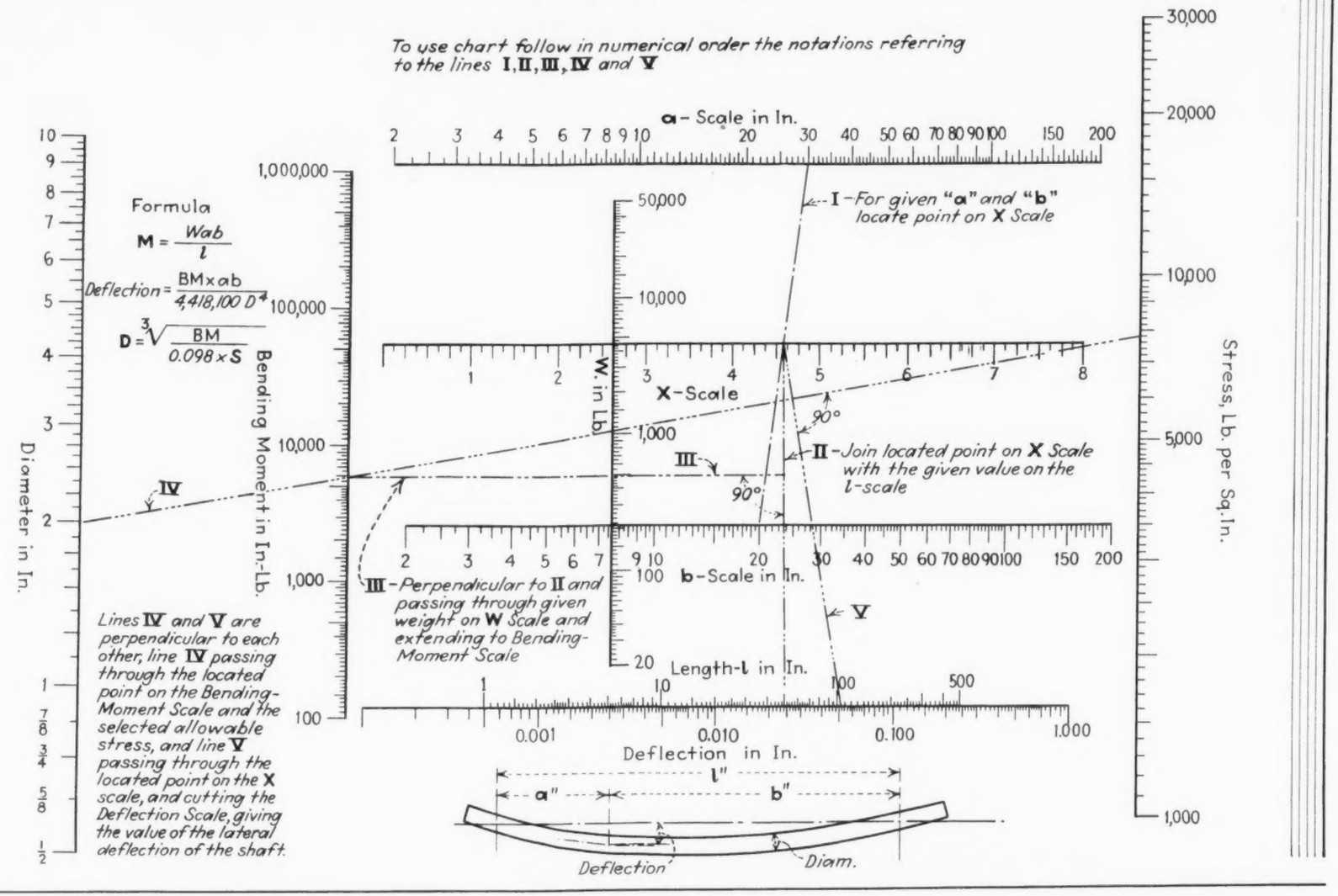
See P.E. May, 1932 p. 227 and 228 for allowable working stresses. Torsional deflection should be limited to 5 min. per ft. of length of shaft.



PRODUCT ENGINEERING © REFERENCE BOOK SHEET

Shaft Diameter for Lateral Deflection

A. D. McKENZIE
The Ohio Brass Company


To use chart follow in numerical order the notations referring to the lines I, II, III, IV and V
a - Scale in In.
2 3 4 5 6 7 8 9 10 20 30 40 50 60 70 80 90 100 150 200
I - For given "a" and "b" locate point on X Scale
Formula
M = Wab / l
Deflection = BM x ab / 4,418,100 D⁴
D = ∛(BM / 0.098 x S)
Diameter in In.
10 9 8 7 6 5 4 3 2 1 7/8 3/4 5/8 1/2
Bending Moment in In.-Lb.
1,000,000 100,000 10,000 1,000 100
W. in Lb.
50,000 10,000 1,000 100 20
X-Scale
1 2 3 4 5 6 7 8
90°
II - Join located point on X Scale with the given value on the l-scale
III
IV
III - Perpendicular to II and passing through given weight on W Scale and extending to Bending-Moment Scale
b - Scale in In.
2 3 4 5 6 7 9 10 20 30 40 50 60 70 80 90 100 150 200
V
Length-l in In.
1 10 100 500
Deflection in In.
0.001 0.010 0.100 1.000
Lines IV and V are perpendicular to each other, line IV passing through the located point on the Bending-Moment Scale and the selected allowable stress, and line V passing through the located point on the X scale, and cutting the Deflection Scale, giving the value of the lateral deflection of the shaft.
l"
a"
b"
Deflection
Diam.
Stress, Lb. per Sq. In.
30,000 20,000 10,000 5,000 1,000